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Natural Resource Assessment of the Barrett's Farm Unit

Minute Man National Historical Park

A view of the southern portion of the Barrett Farm Unit (BFU), looking at the farmland.
NPS / TEÁ MONTAGNA

Natural resource assessment of the Barrett's Farm Unit: Minute Man National Historical Park

Science Report NPS/SR—2024/216

Teá Montagna, Nina McDonnell, Douglas Woodhams, Luis De León, Robert Stevenson

University of Massachusetts, Boston
Biology Department
100 Morrissey Blvd
Boston, MA 02115

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Abstract

This study used a combination of field surveys, historical data, literature review, and formal methods to assess the biodiversity and habitat integrity of vertebrates, excluding mammals at Barrett's Farm unit (BFU).

A one season full inventory of the herpetofauna was completed in 2023. The herpetological survey documented ten species commonly found in Massachusetts (4 frogs, 1 toad, 2 salamanders, 1 snake and 2 turtles), with only one species (*Lithobates pipiens,* Leopard Frog) being seen in large numbers. Several species (*Ambystoma maculatum,* Spotted Salamander; *Dryophytes versicolor,* Gray Treefrog; *Chelydra serpentina,* Snapping Turtle) were only recorded once during the survey.

While no additional inventories were performed, data on several additional vertebrate groups (birds, fish) were examined using historical and participatory science data. Additional assessments included wetland health using amphibians as a metric, examining vegetative communities, and observations of other organisms (mammals, arthropods).

The vertebrate faunal communities of the BFU are of mixed condition. The AmphIBI index of wetland health was conducted on the wetland areas within the unit and found that all but one were in poor health. The remaining wetland that was rated "superior health" can be attributed to low sample size of organisms and is not reflective of the site. The avian community at the unit is interesting as it includes 163 species and is one of the more heavily birded sites in Middlesex County. Formal assessment for breeding forest birds yields a "cautious" rating while a similar process for grassland birds yielded a poor rating. The fish community assessment lacked historical data and participatory science data, so the condition could not be assessed. The habitat at the farm is extremely disturbed from the active farming that occurs, and the edges of the property are heavily colonized by invasive plants, so perhaps the poor quality of the faunal communities is unsurprising.

Several data gaps exist including the lack of assessment of arthropod communities, fish communities, and mammal communities. Additionally, more directed studies of the wetland areas within the unit would be beneficial.

Terms and Abbreviations

NPS: National Park Service

BFU: Barrett's Farm Unit

MIMA: Minute Man National Historical Park

TOC: Town of Concord

DNR: Town of Concord's Division of Natural Resources

MA NHESP: Massachusetts Natural Heritage and Endangered Species Program

amphIBI: Amphibian Index of Biotic Integrity

Acknowledgments

Kiah Walker, Delia Kaye, and Margaret Coffin Brown introduced the UMass Boston Biology Department team to the property and aided in securing permits for the work. We greatly appreciated their guidance, feedback, and encouragement throughout the project. Aaron Weed provided advice and the files necessary to undertake that avian assessment. Phu A Dao, Alex Richards, Dan Montagna, Susan Speak, Kiah Walker, Bill Fuchs, Christian Kishida, Dan Callahan, Marta Lefevre-Levy, Nina Olsen, Ronan Murphy, David Griffith, and the Woodhams family and their three kids assisted with field work. A conversation with Michael Dettelbach while doing field work provided some perspective about visitors to the park. Park Superintendent Simone Monteleone provided overall project guidance.

Several conversations with individuals who grew up on the farm and farmed it for many years provided insights about the property. Email exchanges with Richard T.T. Forman, Brian Donahue, and Ray Angelo clarified questions about the land use and flora of Barrett's Farm. The staff at the Concord Library, especially Jessie Hopper, Assistant Curator, and Anke Voss, Curator of Special Collections, gave RDS access to documents and historical maps related to Barrett's Farm.

The field work and report were prepared under NPS task agreement with the University of Massachusetts Boston, and funding was provided by the Natural Resource Condition Assessment Program.

Introduction

The National Park Service's (NPS) Natural Resource Condition Assessment (NRCA) Program evaluates natural resource **conditions** in park units and delivers the results to park staff, scientists, strategic planners, and the general public through reports and associated products. All NRCA efforts strive to report resource condition information in a way that informs multiple levels of park stewardship activities. Stewardship activities may include partnerships, resource stewardship plans, and park management plans, and may inform on-the-ground actions that park management can readily implement.

Natural Resource Condition Assessments are short-term projects where a pressing issue or critical data or knowledge gap exists. They can be used to evaluate at least one park natural resource, characterize landscape or watershed-scale condition, conduct vulnerability assessments, plan resource restoration, and/or conduct effectiveness evaluations resulting from park management activities. As short-term projects, NRCAs primarily rely on the use and synthesis of existing science and data. They are intended to strengthen our understanding of current resource conditions and their relationship to environmental processes across the landscape, and to improve the delivery of best available science for park management.

Standard products include a detailed project report and associated products. Associated products may be data summaries, resource briefs, geospatial maps and information, story maps, and others. All reports and associated products are available via the NPS Datastore (https://irma.nps.gov/DataStore/).

This report documents and inventories select natural resources in the Barrett's Farm Unit (BFU) a part of the Minute Man National Historical Park (MIMA). Prior natural resource inventories of MIMA did not include the BFU, as it was acquired by the park in 2012 and all prior inventories and assessments were completed prior to that date (Cook et al. 2011; James-Pirri 2009). The report will address the habitats and faunal communities of the BFU, and present opportunities for future work that may be of interest to NPS.

The BFU is a 62-acre parcel within MIMA located in Concord Massachusetts (Middlesex County). It is jointly managed and owned by the Town of Concord (TOC) and the National Park Service (NPS). The NPS owns 3.4 acres containing a historic farmhouse, and TOC owns most of the remaining land within the unit, including both the Natural Resources Division land south of Barrett's Mill Road and Concord School District Land north of the road. Two privately held lots are also within the administrative boundary of the unit. Much of the TOC property within the unit is managed as an organic farm. This active farm is situated on the banks of the Assabet River to the south and Spencer Brook to the east. The western and northern edges are bordered by residential properties. There are several wetlands, surrounded by farmland and edge habitat within the unit. Two distinct woodland types also occur on the unit, a coniferous woodland situated on an esker to the north and a deciduous woodland along the river and brook.

A view looking south of the sign in the parking area of the BFU located off of Barrett's Mill Road. Imaged in June 2023. NPS / ROBERT STEVENSON

The BFU was occupied by Indigenous peoples and later by colonists. The area was likely occupied during the Late Woodland Period (1000 to 450 B.P.). Colonists recorded occupants from the Musketaquid tribe when a colonial settlement was established in 1635 and named Concord. Spencer Brook, which borders the park to the east, was used to power the mill that stood in this area as early as 1678 (Town of Concord Department of Natural Resources 2021). Barrett's Mill Road which bisects the property was named as early as 1730 and today is considered one of Concord's scenic roadways (Town of Concord Department of Natural Resources 2021; Fresella-Lee 2022). During the Revolutionary War, some machinery and arms were made at this mill and stored at the nearby Barrett House, which was built in 1705 by Benjamin Barrett (father of Col. James Barrett) (Town of Concord Department of Natural Resources 2021). The house was originally a small farmhouse but was expanded in 1720 and 1760 and stored most of the munitions for the town and militia (Town of Concord Department of Natural Resources 2021). The house is still present at the site.

The house was named after Colonel James Barrett who was a colonel during the Revolutionary War. When the British army marched on Concord in 1775, they aimed to arrest Col. James Barrett and raid

his house for arms and munitions (Town of Concord Department of Natural Resources 2021). However, thanks to some advance warning he was able to hide most of the stockpile, thwarting the plan (French 1925). Colonel James Barrett died in 1779 (NPS 2021).

The Barrett House and the property it sits on are now owned by the National Park Service. This house is preserved due to its significance and importance leading up to and during the Revolutionary War. This unit was added to the Minute Man National Historical Park in 2012 (NPS 2021). The remaining land encompassed by the BFU is owned by TOC and is considered conservation land. TOC owns two areas within the BFU boundary which are designated as farmland rather than conservation land.

The BFU also includes a series of public trails. Many of the trails follow the edges of the farmland. The loop trail that extends down in the southeastern corner of the unit and along the banks of the Assabet River is known as the Reformatory Branch Trail. This trail and the flattened area adjacent to the trail was once the site of the Middlesex Central Railroad, which served the Concord Reformatory (Town of Concord Department of Natural Resources 2021). The railroad was abandoned in 1927; old railroad ties are still visible within the BFU (Town of Concord Department of Natural Resources 2021).

The current primary use of the BFU is farming. This land has been farmed continually for many centuries. This farm has been owned by the Town of Concord since at least 1905 when it was leased by the McGrath family (Town of Concord Department of Natural Resources 2021). Currently, it is operated by Barrett's Mill Farm, which is an organic farm that supplies locals with produce and has a community supported agriculture program (Barrett's Mill Farm 2024).

The BFU receives high levels of local recreational use. Primary recreational uses of the site include dog walking, hiking/walking, fishing, and observing nature. The site is a well-known and highly utilized bird watching location, especially during spring and fall migratory periods.

Study Site

Current Habitats

The BFU spans 62 acres and contains multiple unique habitat types. We have identified nine categories of habitat types (farmland, edge, roadways and trails, wetlands, ephemeral pools, ditches, Spencer Brook, Assabet River, and woodland) in the unit that will be discussed in greater detail.

Farmland

The BFU includes an active farm, specifically the 15.2-acre Barrett's Farm, which occupies the area southeast of Barrett's Mill Road (Figure 1). There is additional farmland on the west edge of the southern part of the property, and across the roadway which totals an additional 13.98 acres. The total farmland area is approximately 29.18 acres or 46% of the site. While farmland is not often thought of as prime habitat for many species, this habitat can be extremely important to grassland birds (Best et al. 1990; Herzon et al. 2014). This was shown at the BFU and is expanded upon in the bird community faunal assessment.

Farmer operating a tractor on the Barrett's Mill Farm fields. Imaged June 2023. NPS / ROBERT STEVENSON

Figure 1. Farmland at the BFU. Farmland sections at the BFU, each letter designating a contiguous group of farmland. A is the southeastern section, B the southwestern section, and C the northeastern section. On this map, the black lines indicate trails, the yellow line indicates the boundary of the unit, and the rivers and wetlands are marked with a blue and gray wetland indicator symbol. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Farmland at the BFU being tended by a farmer. Imaged June 2023. NPS / ROBERT STEVENSON

Edge

The habitat at the BFU is extremely fragmented, with the large majority of accessible land being edge habitat. Edge habitat can be invaluable to certain species, but detrimental to others, and can cause some pest species to become more prevalent (Anderson et al. 2003; Best et al. 1990; Marini et al. 1995; Nguyen and Nansen 2018). There is approximately 3.41 km of edge habitat at the unit. This approximation excludes the edges on the border of Spencer Brook and the Assabet River.

Image of the edge habitat at the southern edge of the BFU, view looking west. Imaged June 2023. NPS / TEÁ MONTAGNA

Roadways and Trails

Barrett's Mill Road bisects the BFU, separating the habitat into two more or less contiguous areas. Roadways are perilous to animals and are largely considered barriers for species movement especially in fragmented habitat (Shepard et al. 2008). This road likely prevents species of amphibian and reptile from moving about the farm and accessing additional habitat.

There are several looping trails that follow the boundaries of the farmland. At the southeastern edge of the property near the confluence of Spencer Brook and the Assabet River, a loop trail follows the old railroad bed along the river's edge. The majority of trails do not further bisect the habitat, instead following along clear edges. These trails are unlikely to further disrupt faunal communities as they do not bisect contiguous woodland or wetland habitat.

Wetland

For this study, wetlands were defined as any area where the land is covered by shallow water, or the soil is saturated to the surface for 14 consecutive days during the growing season (NPS n.d.). The wetland areas at the BFU are the banks of Spencer Brook and the Assabet River, two ephemeral pools, and two ditches (Figure 2).

Figure 2. Designated wetland areas at BFU. A is the Assabet River and associated floodplain. B is Spencer Brook and associated floodplain. C is one of the ditches located to the northwestern side of the unit. D is the ditch located in the southwestern section of the unit. E is the ephemeral pool located near Spencer Brook. F is the ephemeral pool located behind the Barrett House in the woodland. On this map, the black lines indicate trails, the yellow line indicates the boundary of the unit, and the rivers and wetlands are marked with a blue and gray wetland indicator symbol. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

The wetland areas at the BFU are palustrine (James-Pirri 2009). While a formal assessment of wetlands falls outside of the scope of this study, we assessed wetland health using amphibian breeding activity as a proxy which is discussed in the reptile and amphibian portion of the faunal communities.

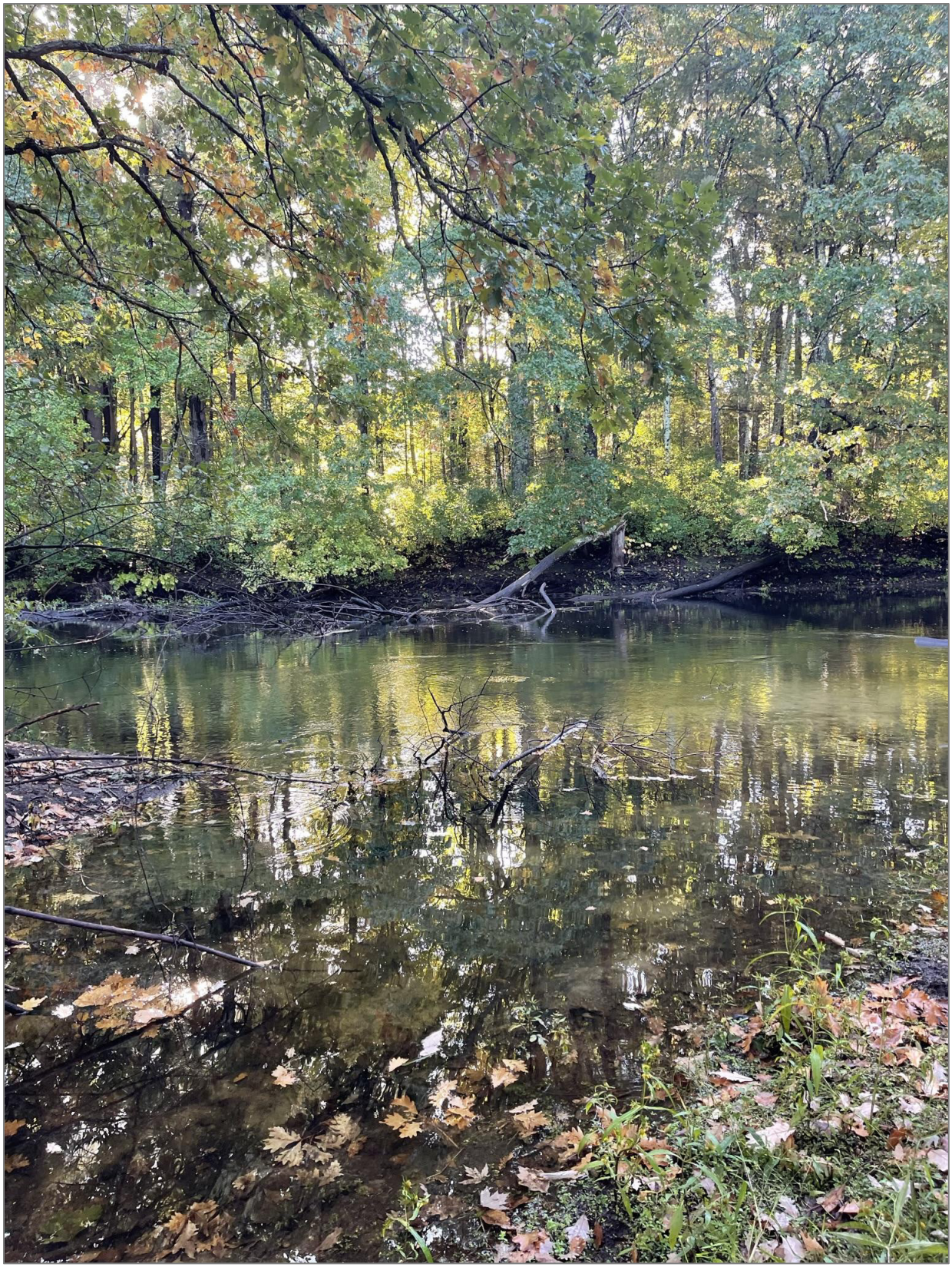

Image of the confluence of Spencer Brook and the Assabet River, view looking south with Spencer Brook in the foreground. Imaged October 2022. NPS / TEÁ MONTAGNA

Ephemeral Pools

There are two ephemeral and fish-less pools in the BFU. The pools vary in size and depth based on precipitation. The first pool, located in April 2023, is located near the banks of Spencer Brook in the thicket of vegetation that borders the paths around the farmland (Figure 2). The second pool, also located in April 2023, is located in the woodland northeast of the Barrett House toward the boundary of the TOC School District parcel (Figure 2). During the 2023 survey window, these pools remained full of water, with some variation in depth. This may have been due to the above average rainfall recorded in 2023 ("2023 Precipitation | Blue Hill Observatory & Science Center" n.d.). Pool F (Figure 2) appears to be in the beginning stages of succession, as in May of 2023, vegetation had formed a mat thick enough to stand on, and the pool had mostly filled with leaves and debris. Ephemeral pools provide habitat for many species of amphibians as well as aquatic invertebrates (Colburn et al. 2007; Paton 2005).

Image of the ephemeral pool located near Spencer Brook (Figure 2). Imaged May 2023. NPS / TEÁ MONTAGNA

Ditches

The BFU has two ditches that remained wet during the 2023 season. These ditches are located behind the farmland to the south of Barrett's Mill Road toward the Assabet River, and across the road to the northern boundary near the western border of the property (Figure 2). These ditches provide

additional non-flowing water sources for amphibians to breed and rehydrate. If these ditches remain full for the majority of the year, they could be considered additional ephemeral pools. However, it is unclear whether these ditches typically remain filled with water, particularly in years with only average precipitation.

Spencer Brook

Spencer Brook is a perennial stream, meaning it has flowing surface water in at least parts of the streambed throughout the year. Spencer Brook begins to the north at Buttrick Pond in Carlisle, Massachusetts and flows south, traveling under Barrett's Mill Road to the Assabet River. Spencer Brook forms the eastern boundary of the BFU (Figure 2). At the first site visit in October 2022, the brook was very shallow and contained within its banks. At subsequent visits in 2023, the brook was flowing at a faster pace, and had overflowed its banks in numerous spots. In some cases, the entire floodplain was under water up to the edge of the farmland. The floodplain that borders the brook is unique habitat and is discussed further in the vegetation communities section.

Image of Spencer Brook looking through the floodplain, view looking east. Imaged October 2022. NPS / TEÁ MONTAGNA

Assabet River

The Assabet River begins to the west in Westborough Massachusetts, and flows about 34 miles to Concord, before meeting the Sudbury River and becoming the Concord River. The confluence of the Assabet and Sudbury Rivers is approximately 2.3 km downstream of the BFU. The Assabet River makes up the southern border of the unit and is an important water resource for both the humans and animals in the area (Figure 2). The farm uses water from the river to irrigate the fields. The riverbanks are additional floodplain habitat.

View from the north bank of the Assabet River looking southwest. Imaged October 2022. NPS / TEÁ MONTAGNA

Woodland

Two locations within the BFU are considered woodland. The first is the area behind the Barrett House, at the northern edge of the property, and the second is the eastern and southern portion of the property, along the brook and the river. The northern edge of the property behind the Barrett House is largely dominated by tall conifers. The eastern and southern edges of the boundary are dominated entirely by deciduous trees. The specific composition of plants in these areas is discussed later in the vegetative communities section.

View looking north from the Barrett House through the blueberry patch within the BFU toward the ridge, which is outside the BFU and owned by TOC who manages it for conservation and recreation. Coniferous trees dominate the wooded hillside. Imaged October 2022. NPS / TEÁ MONTAGNA

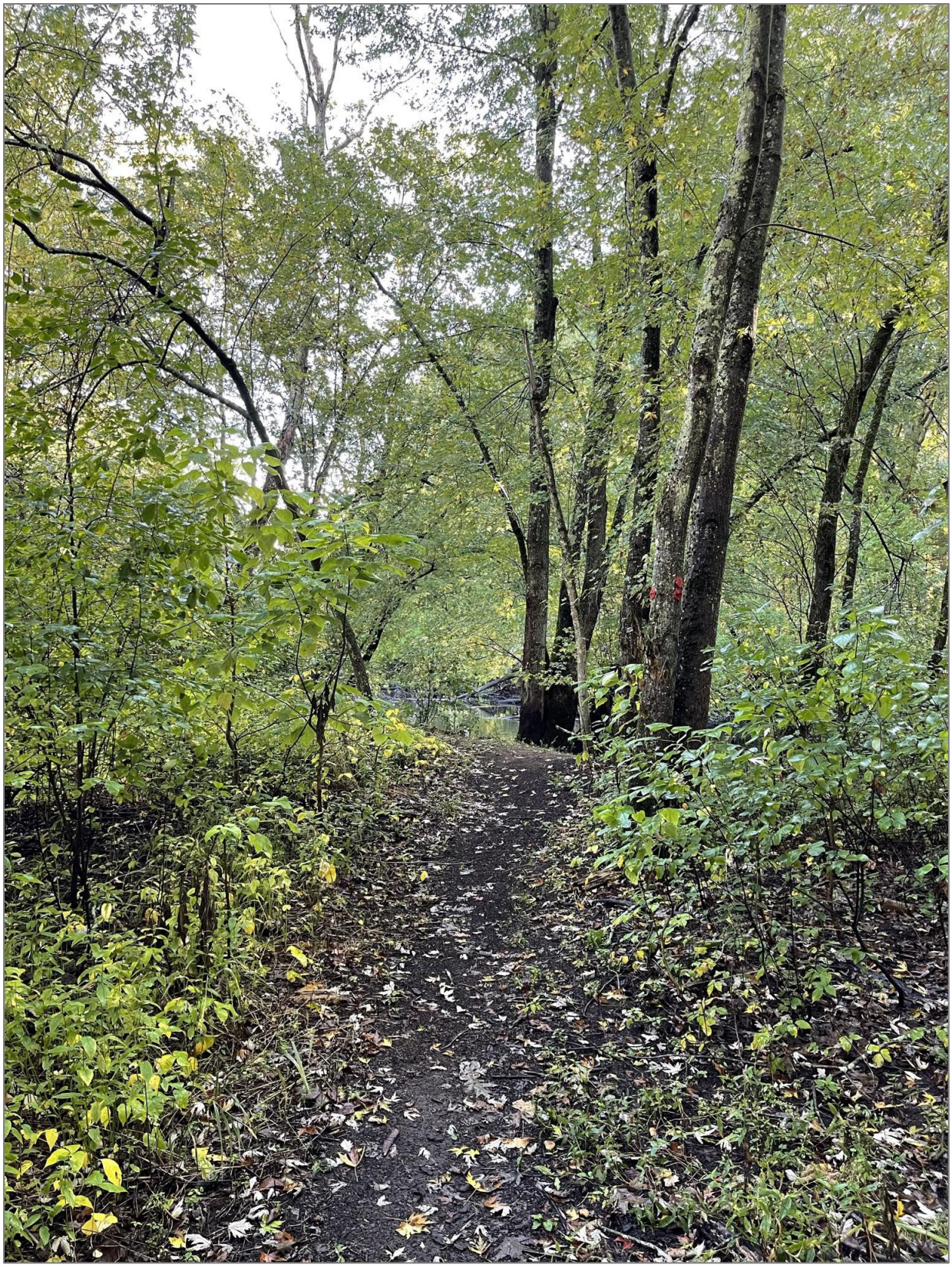

Image of the deciduous woodland near the Assabet River, view looking south. Imaged October 2022. NPS / TEÁ MONTAGNA

Vegetative Communities

A previous summary of the ecological landscape by TOC in 2021 divided the farm into seven sections, each with unique vegetation (Forman et al. 2021). The vegetation was generally described as follows. The section closest to the water (southeastern corner) includes a very large branching *Acer saccharinum* by the confluence of Spencer Brook and the Assabet River, along with other *A. saccharinum* and species of *Quercus* (Forman et al. 2021). The sections continuing along the southern edge of the paths are primarily edge habitat. The summary listed several species of invasive plants in these sections which were also observed in this faunal assessment. The section on the northern side of the unit is described as primarily *Pinus* and *Quercus* (Forman et al. 2021).

While a formal vegetative assessment was not a part of this faunal community assessment, we can make several generalizations based on observations made while surveying the landscape for herpetofauna. The primary vegetative communities noted are wetland and floodplain communities, edge communities, woodland communities, and farmland communities. These are broad generalizations and are meant to give a sense of the habitat at the unit rather than an exhaustive inventory of the vegetation. These communities are detailed below.

Wetland and Floodplain Vegetation

The vegetation along Spencer Brook and the Assabet River is dominated by obligate and facultative wetland plants that are indicative of areas that have perennially or seasonally saturated soils or flood frequently. Along the banks of Spencer Brook, a wide array of herbaceous plants and vines including *Bidens, Toxicodendron, Vitis, Parthenocissus,* and assorted grasses, sedges, and ferns persist. They are joined by many water-loving shrubs including *Cephalanthus, Vaccinium, Ilex, Cornus amomum,* and *Diervilla.* The trees in this area are deciduous, with no conifers found on the floodplain. The primary tree species include *Acer, Quercus*, *Salix, Ulmus, Tilia,* and *Fraxinus.*

A view of the floodplain of Spencer Brook, looking east. Imaged October 2022. NPS / TEÁ MONTAGNA

Edge Habitat Vegetation

Along the edges of the property, including the farmland edge and roadsides a variety of herbaceous groundcovers, weedy plants, and invasive plants thrive. The thickets directly adjacent to the paths bordering the farmland are comprised almost entirely of invasive species. The primary composition includes the Japanese *Lonicera* complex, *Cornus kousa, Rosa multiflora*, *Celastrum orbiculatus, Phellodendron amurense,* and *Rhamnus cathartica*. Mixed sporadically throughout are native plants that can tolerate the invasion such as *Prunus serotina, Rhus typhina*, and *Juglans.*

Image of the edge habitat at the southern edge of the BFU, looking west. A resting *Sylvilagus floridanus* (Eastern Cottontail) sits in the center of the image. Imaged June 2023. NPS / ROBERT STEVENSON

Woodland Vegetation

The woodland behind the Barrett House along the northern boundary of the park is primarily tall *Pinus strobus*. There are some smaller trees like *Quercus* and *Prunus* mixed in, but the majority of the forest is tall growing trees with minimal understory except along the edge. The woodland that borders the brook and the river is discussed in the wetland and floodplain vegetation subsection of the vegetative communities.

Farmland Vegetation

As stated, much of the BFU is an active farm. The farmland itself has over 50 types of vegetable, fruit, and flower growing on it (Barrett's Mill Farm 2024). These are clearly not wild plants, but these are important food resources for many species of grassland birds, insects, and some mammals. In areas that were left fallow for 2023, a variety of weedy herbaceous plants and vines grow, including native plants such as *Asclepias syriaca, Solidago, Sympyhotrichum,* and *Echinocystis lobata*. Many non-native plants grow in these fields including *Silene flos-cuculi*, *Lamium purpureum, Daucus carota,* and assorted *Brassica.*

View looking southwest of one of the farm fields at the BFU, south of Barrett's Mill Road. Imaged June 2023. NPS / TEÁ MONTAGNA

Faunal Communities

The scope of the assessment of vertebrate communities at the BFU included an inventory of the herpetofauna including field work, historical records, and participatory science data, as well as examination of historical records and participatory science data for birds and fish. Formal field assessments were limited to herpetofauna. Casual observations of other vertebrate taxa that occurred during the herpetofaunal work were noted.

In this section, we detail the methodology and results of the herpetological survey, discussing the health of wetlands and comparing the findings to what was uncovered at MIMA in prior surveys. While no field surveys were completed, the historical and participatory science data for birds at the BFU is rich and allowed for comparison to the findings from MIMA. The fish data was sparse in comparison to data on other vertebrate taxa, and we were unable to conduct a formal assessment of this group. Additional observations of mammals and arthropods are also described.

Reptiles and Amphibians

Methods

Coverboard Survey

The Barrett Farm unit survey adopted the coverboard methodology that was employed in the Herpetological Survey of the Minute Man National Historical Park (MIMA) in 2001 (Cook et al. 2011). Coverboards are routinely employed for herpetological surveys (Cook et al. 2011; Grant et al. 1992; Halliday and Blouin-Demers 2015; Nordberg and Schwarzkopf 2015; Sung et al. 2011). Coverboards are wooden boards or metal sheets placed on the ground to allow reptiles and amphibians to seek shelter under them (Grant et al. 1992; Halliday and Blouin-Demers 2015; Nordberg and Schwarzkopf 2015; Sung et al. 2011). Microclimates can form under coverboards, creating ideal conditions for reptiles and amphibians to seek shelter (Dodd 2010). Typically, wooden boards attract amphibians and metal sheets attract reptiles (Dodd 2010). Boards do not absorb much heat, making them more attractive to amphibians, whereas metal sheeting does absorb heat, making it more attractive to reptiles. In the survey of BFU, we used both methods.

We placed a total of 29 coverboards, 16 wood (exterior plywood 2' by 4' and 1.25" thick) and 13 metal (corrugated roofing 2' by 4' and 0.25" thick) (Figure 3). Cover was placed throughout the site in edge habitat, in woodland habitat, adjacent to seasonal pools and wetlands, and along river and stream beds (Figure 4). Boards of the same type were spread at least 20 meters apart. However, a metal sheet and a wooden board were typically placed near each other to facilitate attraction of both reptiles and amphibians within the same general area. Coverboards were placed in two rounds, the first in March 2023 and the second in April 2023. They remained out for the entire 2023 calendar year. Checks of coverboards occurred weekly or bi-weekly throughout the spring and summer. The first check of the cover was March 24, 2023, and the final checks were September 15, 2023. This date range captures the majority of time that reptiles and amphibians are active in Massachusetts (Government of Massachusetts 2023).

Figure 3. Images of the wooden and metal coverboards. Wooden coverboards measured 2' by 4' by 1.25" and metal sheets measured 2' by 4' by 0.25". NPS / NINA MCDONNELL

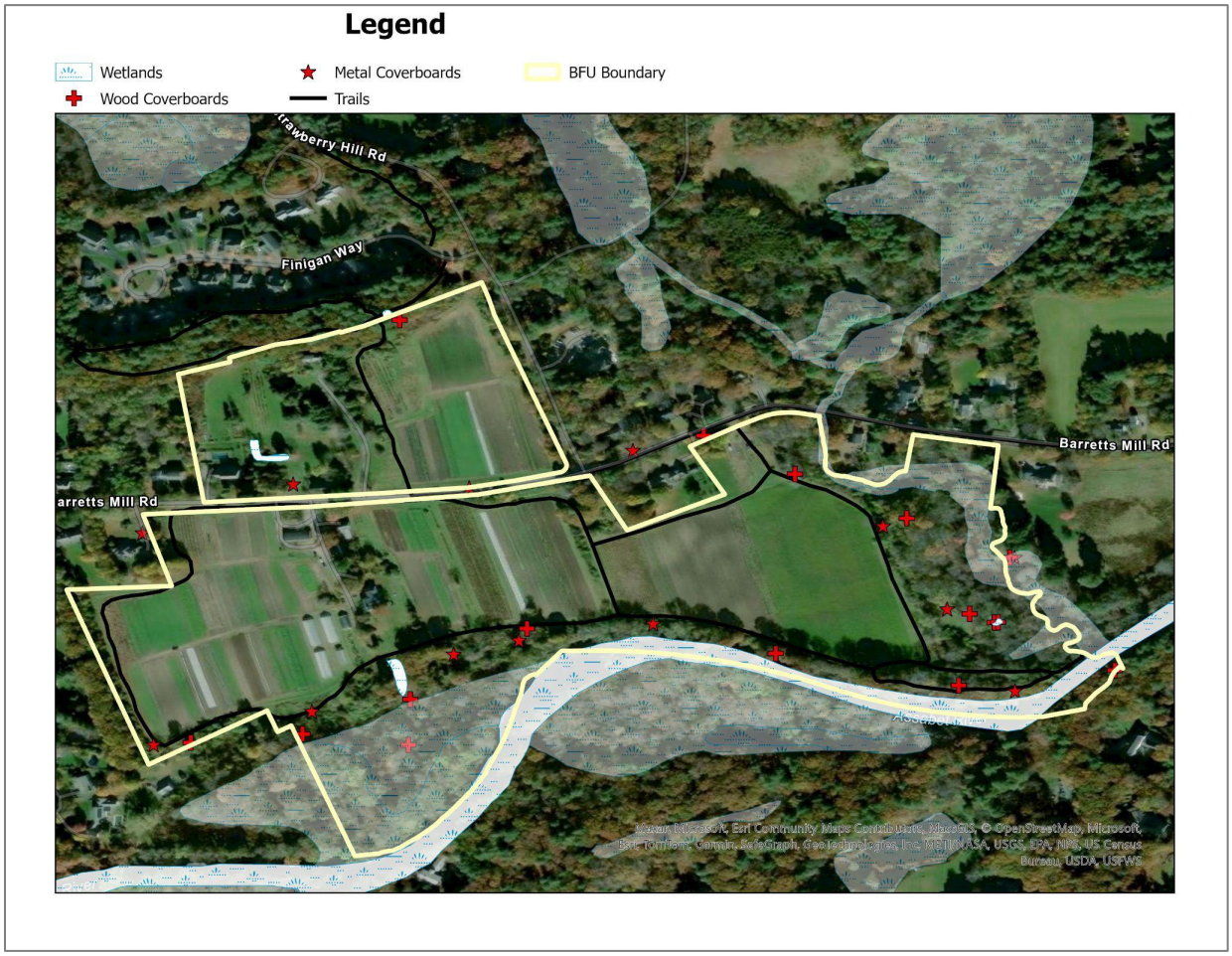

Figure 4. Locations of metal and wood coverboards placed in the 2023 season at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

During the survey, seven coverboards went missing due to a combination of natural and human causes. Specifically, several metal boards placed by the roadsides and trails were likely taken or

moved by people. In addition, during 2023, Massachusetts received significantly more rain than average, totaling 58.7 inches of rain, approximately 10 inches above average in a year ("2023 Precipitation | Blue Hill Observatory & Science Center" n.d.). This caused extensive flooding of both Spencer Brook and the Assabet River, which washed away several coverboards located near these bodies of water.

Incidental Encounters

While walking the site, we recorded incidental encounters of reptiles and amphibians. These incidental encounters provide valuable supplemental data, given that not all amphibians and reptiles tend to seek cover under the coverboards. The data recorded for an incidental encounter includes species, number of individuals, location, and method of observation (visual encounter or vocal encounter). The incidental encounters took place in the same survey period as the coverboards from March to September. The first organism recorded by this method was on April 1, 2023, and the final observation on September 15, 2023.

Environmental DNA

In addition to traditional survey methods, we employed environmental DNA ("eDNA") sampling to improve detection of elusive species. This method is based on the premise that organisms inhabiting an environment will shed genetic material through waste, mucus secretions, dead cells, and other products. If this material can be collected, such as in a water or soil sample, the nucleic acids can be extracted and replicated via polymerase chain reaction (PCR) to generate a library of DNA to be used for species identification.

To sample eDNA over the active season, samples were collected from each of eight sources on the BFU (Table 1, Figure 5). Samples were collected in April, July, and October, when reptiles or amphibian activity were observed via visual encounter surveys. Each water sample was collected in four 250 mL Nalgene bottles (total volume of 1-liter per site) which had been pretreated with 20% bleach to degrade any pre-existing nucleic acids. Stratified samples were collected from four opposite points of each water source, at least one meter from the shore to reduce edge effects and excessive debris, which can pose a challenge to DNA extraction. Sterile techniques, including DNA-free nitrile gloves and sample transportation bins, were used during sample collection to reduce the risk of sample contamination from non-target sources. This is an important consideration in eDNA work, as contaminant DNA from researchers and laboratory surfaces can easily overwhelm sparse environmental samples. Samples were transported to UMass Boston on ice packs and frozen at −20°C until processing.

Table 1. Dates and locations of eDNA samples collected from BFU in 2023. Numbers in parentheses refer to the locations in Figure 5.

eDNA Sample Site	Coordinates	Timepoints Sampled	Dates Sampled (2023)
Pool North (4)	42.474484, −71.380134	4	April 1–October 10
Pool South (8)	42.469060, −71.381410	4	April 20–October 10

Table 1 (continued). Dates and locations of eDNA samples collected from BFU in 2023. Numbers in parentheses refer to the locations in Figure 5.

eDNA Sample Site	Coordinates	Timepoints Sampled	Dates Sampled (2023)
Drain North (3)	42.473249, −71.381205	3	April 25–October 10
Drain South (2)	42.471297, −71.380161	3	April 25–October 10
Assabet River (1)	42.471038, −71.375645	3	April 25–October 10
Outlet (7)	42.471662, −71.373262	3	April 25–October 10
Spencer Brook (5)	42.472937, −71.374505	3	April 25–October 10
Fairy Pool (6)	42.472163, −71.374349	3	April 25–October 10

Figure 5. Locations of eDNA sampling. Each number indicates a site. 1 is the Assabet River, 2 is the drainage ditch in the southern portion of the unit, 3 is the drainage ditch in the northern portion of the unit, 4 is the ephemeral pool in the northern portion of the unit, 5 is Spencer Brook, 6 is the ephemeral pool in the southern portion of the unit, 7 is the confluence of Spencer Brook and the Assabet River, and 8 is a small pool near the banks of the Assabet River. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

To collect eDNA from the water, each sample was first passed through a 20-micron filter to remove coarse debris, then through a 5-micron filter. This pore size is sufficient to collect DNA passing over the membrane as it becomes bound with fine particles (Thomas et al. 2018). All filtration apparatuses were treated with 20% bleach and rinsed with DNA-free water (MilliQ ddH_2O) before and between filtrations to prevent sample cross-contamination. DNA from 5-micron filters was extracted using gMax Mini Genomic DNA kits and Soil DNA kits (IBI Scientific) according to manufacturer protocols with all outlined measures to minimize metallic and humic residues while maximizing DNA yield (repeated wash steps, and salt-binding steps, and elution steps). To ensure that any contaminants from sample processing were diagnosed and treated appropriately, a negative control sample containing DNA-free water was filtered and extracted following the same procedure as diagnostic samples. Because samples from April and July were extracted with the Genomic DNA kit, which did not eliminate all PCR-inhibiting residues, additional inhibitor-removal steps were performed with a DNeasy PowerClean Pro kit (QIAGEN). The numerous extraction processes used to remove inhibitors from these samples may have reduced DNA yield and increased the risk of contamination from introduced human sources. To overcome low yield, DNA from the 20-micron pre-filters of the same time points was extracted using the Soil DNA kit, amplified, and pooled with the corresponding 5-micron filter PCR products.

Clean, purified DNA was used to generate a sequencing library: Each sample was amplified by PCR targeting the mitochondrial 16S rRNA gene. This genomic region is an effective target for profiling many taxa because it is subject to few selective pressures and gradually accumulates mutations in isolated populations through genetic drift (Woese and Fox 1977, 161; Kamble et al. 2020). This allows for many species to be discerned based on genetic sequence. Due to the relative ease of amphibian mitochondrial genome sequencing compared to nuclear genomics, reference sequences are available for many species. Our primers targeted the 1070F-1340R position, which is optimized for discriminating between amphibian taxa (Sakata et al. 2021). Primers were specially designed to facilitate a single-PCR amplification and barcoding step during library prep by inserting the target sequences into Earth Microbiome Project's library preparation and sequencing constructs (Thompson et al. 2017). Reactions were prepared in 25 uL duplicates, using 2x Taq Red Mix (Azura Genoics) with 1–4 uL template DNA extract (input volume varied based on individual sample DNA and inhibitor concentrations) and 0.013% DNA-free Recombinant Albumin to reduce inhibitor binding and improve yield. PCRs were run for 40 cycles with a 30 second denaturing step at 94°C, 30 second annealing step at 54°C, and 40 second extension step at 72°C. Duplicate products were pooled, then successful amplification was confirmed via gel electrophoresis. Due to the high concentrations of PCR-inhibitors in Barrett's Farm water samples, several data points were excluded from sequencing. Excluded samples were either unresponsive to inhibitor-removal treatments (no mitochondrial amplicons were visible when checked by gel electrophoresis) or showed streaking, indicative of problematic product. These included the Assabet River samples from April 25th and July 29th, and the Spencer Outlet sample from April 25th. The remaining samples were normalized with a SequalPrep Normalization Plate Kit. Then, 10 uL of each normalized sample was pooled to form the sequencing library. This was loaded onto the Illumina MiSeq (150 cycle kit, V3 chemistry) to obtain raw reads.

Pooled sample reads were imported to Qiime2 using the Earth Microbiome Protocol format and quality-filtered to a minimum Phred score of 20 (base call accuracy of 99 percent). Then, forward and reverse sequences were merged, dereplicated, and clustered into amplicon sequence variants (ASVs) with 97 percent sequence similarity using vsearch (Rognes et al. 2016). Taxonomy was assigned to the consensus mitochondrial sequences based on NCBI's mitochondrial database, using Blastn. Ideally, samples would have been indexed with unique barcodes or run as a single pooled sequencing library. However, due to the small size of this dataset and unexpected incompatibility of our newly developed indexing primer with concurrent library formulations, it was run alongside a marine library. Marine features were then excluded from the Barrett Farm dataset based on reference species habitat type. ASVs matching reference mitochondrial features at less than 97 percent sequence identity were excluded from taxonomic analyses, as were invertebrate animals for which the primer set was not optimized. Invertebrate reads corresponding to features which passed the 97 percent sequence identity threshold were grouped into an "NA" taxonomic category for context. Because our primers were designed for tetrapod species (specifically Amphibia), taxonomic assignments for Actinopterygii, Aves, and Mammalia were validated by aligning the mitochondrial sequences of the closest Blastn match to sister taxa to ensure that assignments were unambiguous. If assignments were ambiguous, results were reported at the finest level of taxonomic resolution possible.

Results

Coverboard Survey Results

Only three species were recorded under coverboards during the duration of this survey: two species of amphibian, and one species of reptile (Table 2). The most frequent encounter was *Thamnophis sirtalis* (Eastern Garter Snake) with 15 individuals encountered under cover (Table 2). *Thamnophis sirtalis* was recorded more frequently under metal cover (n=12) but was recorded under wood cover (n=3) as well. The second most frequently encountered species under cover was *Plethodon cinereus* (Redback Salamander) with five encounters (Table 2). This species was observed exclusively under wooden cover (n=5). The third encountered species under cover was *Lithobates clamitans* (Green Frog) with four encounters total (Table 2). This species was also seen exclusively under wooden cover (n=4).

Table 2. Dates and species of herpetofauna recovered under coverboards.

Date	***Lithobates clamitans*** **(Green Frog)**	***Plethodon cinereus*** **(Redback Salamander)**	***Thamnophis sirtalis*** **(Garter Snake)**
4/6/2023	0	1	0
4/20/2023	0	0	1
4/29/2023	0	0	1
5/6/2023	0	0	1
5/10/2023	1	1	0
5/31/2023	0	1	0

Table 2 (continued). Dates and species of herpetofauna recovered under coverboards.

Date	*Lithobates clamitans* (Green Frog)	*Plethodon cinereus* (Redback Salamander)	*Thamnophis sirtalis* (Garter Snake)
6/12/2023	0	0	3
6/15/2023	0	0	1
6/23/2023	0	0	1
6/30/2023	1	0	2
7/7/2023	1	0	1
7/15/2023	0	0	1
9/3/2023	0	0	1
9/8/2023	0	1	2
9/15/2023	1	1	0

Thamnophis sirtalis was seen under cover over the majority of the season with the first observation in April and the latest in September. *Plethodon cinereus* was seen under cover during the Spring and Summer months, from April to May, and then again in September. This is consistent with typical salamander behavior in Massachusetts (Government of Massachusetts 2023). *Lithobates clamitans* was seen under cover in May, June, July, and September but sporadically. The phenology of these species is discussed in greater depth in the species account section.

Incidental Encounter Results

A total of nine species were recorded incidentally, including six amphibians and three reptiles (Table 3). Most incidental encounters were visual (n=97); however, several were vocal encounters (n=4) (Table 3). Notably, *Dryophytes versicolor* (Gray Treefrog) was encountered once during the survey period, and only recorded by call (Table 3). Of particular interest was the abundance of *Lithobates pipiens* (Northern Leopard Frog), with a total of 52 individuals recorded (Table 3).

Table 3. Incidental encounters of species with method of encounter.

Species	Visual Encounter	Vocal Encounter
Ambystoma maculatum (Spotted Salamander)	3	0
Anaxyrus americanus (American Toad)	2	1
Chelydra serpentina (Snapping Turtle)	1	0
Chrysemys picta (Painted Turtle)	2	0
Dryophytes versicolor (Gray Treefrog)	0	1

Table 3 (continued). Incidental encounters of species with method of encounter.

Species	Visual Encounter	Vocal Encounter
Lithobates catesbeianus (Bullfrog)	2	0
Lithobates clamitans (Green Frog)	28	3
Lithobates pipiens (Leopard Frog)	52	0
Thamnophis sirtalis (Garter Snake)	8	0

Lithobates clamitans (Green Frog) and *Lithobates pipiens* were both seen throughout most of the survey period (Table 4). The remainder of species were seen more sporadically and less predictably. The phenology of each individual species is discussed in greater detail in the species account section.

Table 4. Number of individuals of each species encountered incidentally by month of survey.

Species Name	April	May	June	July	September
Ambystoma maculatum	3	0	0	0	0
Anaxyrus americanus	1	0	0	1	1
Chelydra serpentina	0	0	1	0	0
Chrysemys picta	0	1	1	0	0
Dryophytes versicolor	0	1	0	0	0
Lithobates catesbeianus	0	0	0	0	2
Lithobates clamitans	11	15	2	1	2
Lithobates pipiens	4	7	8	9	24
Thamnophis sirtalis	0	3	2	0	2

Environmental DNA Results

Our BFU sequence data matched to reference mitochondria of *Lithobates pipiens, Lithobates clamitans, Lithobates sylvaticus* (Wood Frog), *Anaxyrus americanus,* and *Dryophytes versicolor. L. pipiens, L. clamitans, D. versicolor*, and *A. americanus* were also observed during our visual and vocal encounter surveys. However, we did not directly observe *L. sylvaticus*. *L. sylvaticus* may have eluded observation if it was breeding in the South Pool (Figure 2), which was not surveyed until late April of 2023, well after the species' breeding period that year. This fishless site is characterized by shallow, brambly and emergent vegetation that receives partial sun after leaf emergence. The species was not breeding in the apparently suitable North Pool or Fairy Pool (named for the presence of *Eubranchipus vernalis*, discussed in the Arthropoda section) in early April of 2023, when *Ambystoma maculatum* eggs were observed. These two species typically deposit egg masses under similar spring conditions, so we expect to observe them in the same period. Outside of the breeding

season, *L. sylvaticus* is well-camouflaged in leaf litter. Therefore, it is feasible that we missed this species through visual surveys. *D. versicolor* can also be challenging to find outside of the breeding period, as it is primarily arboreal. We heard sparse calls in the lands adjacent to the farm in July. This species may also find the South Pool floodplain to be suitable breeding habitat. Interestingly, we did not detect *Ambystoma maculatum* through eDNA, despite collecting a sample while eggs were in the water. Given that this was the first eDNA sample we collected, improper technique to avoid human DNA contamination could be responsible. In such cases, sequencing depth of target taxa can be dramatically reduced.

In interpreting these results, it is important to consider the transportation and residence time of eDNA. For relatively small sites, such as Barrett's Farm, DNA may be carried from adjacent sites through waterways, such as the Assabet River. Therefore, it is possible that positive detections reflect the areas adjacent to the property in addition to the land itself. In the future, sample barcoding would help to obtain finer resolution eDNA data from the landscape. This would allow us to identify which microsite and timepoint a given identification came from, and hence the potential for bias from surrounding biotic communities. For instance, samples from flowing waterways can be expected to contain higher abundance of DNA originating off-site than those collected from self-contained pools.

Though they were not the target of our primer set, many macroinvertebrate mitochondrial sequences were amplified in our library preparation process. These biologically important taxa could not be accurately identified from the 1070F-1340R target region (Figure 6). These organisms have been considered as an obstacle to eDNA monitoring by other researcher groups. While it has been reported that they do not consume and degrade eDNA particles sufficiently to impact target species detection (Mächler et al. 2018), we found that they can limit the finite sequencing reads corresponding to vertebrates by contributing vast quantities of their own genetic material. If possible, future work may benefit from primers which either: 1) do not amplify these organisms or 2) target a larger gene fragment suitable for their identification.

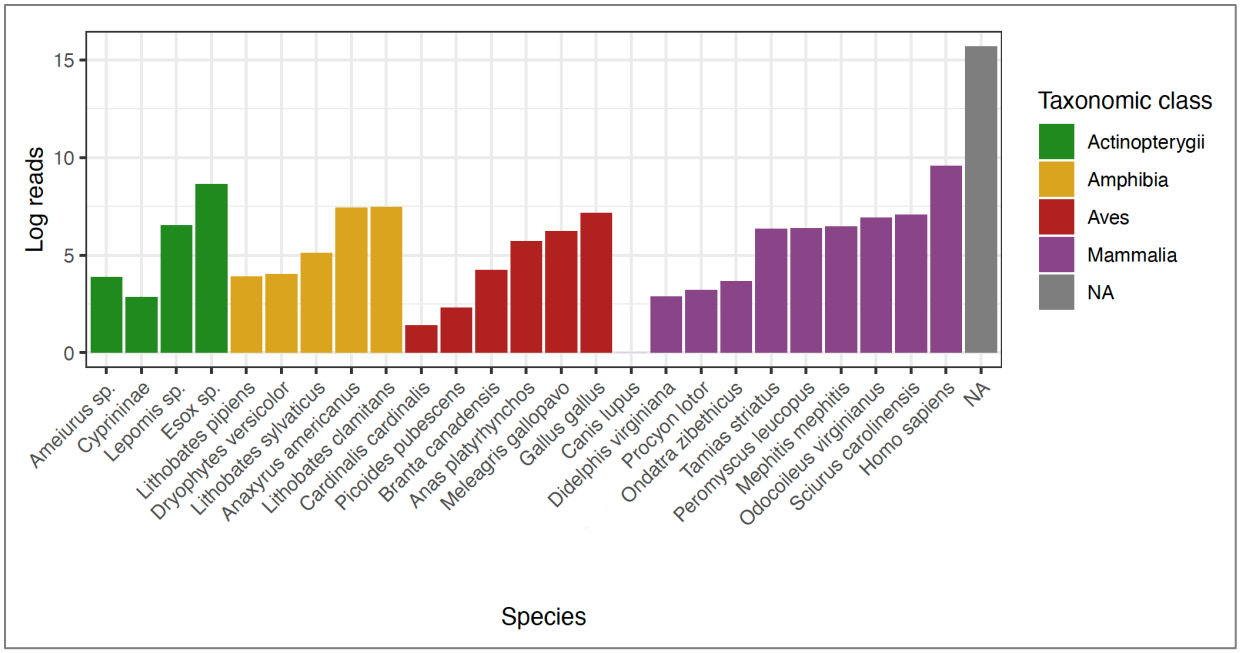

Figure 6. Taxonomic composition of eDNA sequencing reads with 97-percent or greater sequence identity to NCBI mitochondrial references. Features are reported at the finest taxonomic resolution discernible. Invertebrate features that passed our sequence identity threshold are grouped into a single "NA" taxonomic class, as they could not be reliably identified. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

AmphIBI Index of Wetland Health

To allow for comparison to the larger MIMA site, a list of species with relative abundance was generated, and the Amphibian Index of Biotic Integrity (amphIBI) was performed for each wetland area at the unit (Figure 2, Tables 5 and 6) (Micacchion 2011; Cook et al. 2011). There were fewer individuals recorded at the BFU (n = 117) than in other portions of the park (n = 1540). This pattern holds for both reptiles (BFU n = 18; other portions of the park n = 80) and amphibians (BFU n = 101; other portions of the park n = 1460) (Table 5). The AmphIBI index is used to describe the biotic integrity of wetlands using amphibian presence as a metric (Micacchion 2011). This index showed that all wetlands except Wetland F were of poor quality, with Wetland F ranking as "superior" (Figure 2, Table 5). This does not reflect the reality of this wetland and is a product of only a few individuals being recorded in the area which is expanded upon in the discussion.

Table 5. AmphIBI index of wetland health performed on the wetland areas at the BMF unit.

Site	Amphibian Quality Assessment Index (AQAI)	Relative Abundance of Sensitive Species	Relative Abundance of Tolerant Species	Number of Pond Breeding Species	Presence of *Ambystoma maculatum* or *Lithobates sylvestris*	Condition Score
Wetland A	3.33 (Score = 3)	0% (Score = 0)	100% (Score = 0)	0	N	3 (Limited Wetland Habitat)
Wetland B	3.14 (Score = 3)	0% (Score = 0)	100% (Score = 0)	0	N	3 (Limited Wetland Habitat)
Wetland C	4 (Score = 3)	0% (Score = 0)	100% (Score = 0)	0	N	3 (Limited Wetland Habitat)
Wetland D	1.75 (Score = 0)	0% (Score = 0)	100% (Score = 0)	0	N	0 (Limited Wetland Habitat)
Wetland E	1.5 (Score = 0)	0% (Score = 0)	100% (Score = 0)	0	N	0 (Limited Wetland Habitat)
Wetland F	6.25 (Score = 10)	75% (Score = 10)	25% (Score = 7)	3 (Score = 7)	Y (+10)	44 (Superior Wetland Habitat)

Table 6. Species list of recovered herpetofauna at the BMF unit through field surveys. Relative abundance of each species is given along with the total number of individuals. The relative abundance and total number of individuals of those same species found at MIMA is also given for comparison.

Category	Species	Relative Abundance	Total Individuals	MIMA Relative Abundance	MIMA Total Individuals
Reptiles	*Chrysemys picta* (Painted Turtle)	11.11%	2	20.00%	16
	Chelydra serpentina (Snapping Turtle)	5.56%	1	27.50%	22
	Thamnophis sirtalis (Garter Snake)	83.33%	15	52.50%	42
	Total Reptiles	**–**	**18**	**–**	**80**
Amphibians	*Ambystoma maculatum* (Spotted Salamander)	2.97%	3	4.18%	61
	Plethodon cinereus (Redback Salamander)	6.93%	7	5.27%	77

Table 6 (continued). Species list of recovered herpetofauna at the BMF unit through field surveys. Relative abundance of each species is given along with the total number of individuals. The relative abundance and total number of individuals of those same species found at MIMA is also given for comparison.

Category	Species	Relative Abundance	Total Individuals	MIMA Relative Abundance	MIMA Total Individuals
Amphibians (continued)	*Anaxyrus americanus* (American Toad)	2.97%	3	1.16%	17
	Dryophytes versicolor (Gray Treefrog)	0.99%	1	42.12%	615
	Lithobates catesbeianus (Bullfrog)	1.98%	2	5.48%	80
	Lithobates clamitans (Green Frog)	32.67%	33	39.93%	583
	Lithobates pipiens (Leopard Frog)	51.49%	52	1.85%	27
	Total Amphibians	**–**	**101**	**–**	**1460**

Discussion

The most recent herpetological inventory in MIMA was conducted in 2001 and did not include the more recently acquired BFU (Cook et al. 2011; James-Pirri 2009). The other areas of MIMA are significantly larger and more diverse in habitat than BFU, resulting in greater abundance and diversity of herpetofauna detected in previous studies compared to our current study at BFU (Cook et al. 2011). Twenty-three species have historically been recorded at MIMA, with 17 recovered in the most recent park-wide survey which predates the addition of the BFU to the park (Cook et al. 2011; James-Pirri 2009) (Table 6). Our survey at the BFU recorded only 10 species. There is a complete overlap in species found at BFU with those found at other areas of MIMA. All of the herpetofauna recovered at BFU rank as "least concern" and are not state listed (Government of Massachusetts 2023). Efforts were made to locate *Emydoidea blandingii* (Blanding's Turtle) which has been seen in other parts of MIMA, however no suitable habitat for this species exists at the BFU, nor were any individuals seen during the survey.

Given that there have not been prior surveys at the BFU, we are unable to determine overall population trends. Several common species found in Massachusetts such as *Plethodon cinereus* and *Anaxyrus americanus* were only recorded five and three times respectively at the BFU throughout the survey period. However, a species with disjunct populations throughout the state, *Lithobates pipiens,* was recorded 52 times. The abundance of this anuran species is likely due to the adjacent Crowley Land, a wetland where they are likely breeding as it is less disturbed. There are several known populations in Concord of *L. pipiens*, and they are locally abundant along the Assabet and Concord River floodplains.

One metric to assess wetland habitat quality is the AmphIBI Index developed by Ohio's Environmental Protection Agency (Micacchion 2011). This assessment utilizes five metrics related to amphibian presence and abundance to assess whether or not wetlands are in good or poor quality (Micacchion 2011). *Ambystoma maculatum* and *Lithobates sylvaticus* are the two species the AmphIBI index considers indicators of good wetland health (Micacchion 2011). *Lithobates sylvaticus* was not recorded during any of our direct surveys. The AmphIBI index was applied to the BFU data to align with the prior MIMA Natural Resource Assessment (Cook et al. 2011). At the unit, there are six areas that qualify as wetlands (Figure 2). There are two ephemeral pools on the property (Figure 2) that host amphibian life. There are several ditches with semi-permanent water (C, D in Figure 2) that also had amphibians in them. The last two areas are the wetlands along the banks of the river or brook (Figure 2). The first metric, AQAI (Amphibian Quality Assessment Index) showed that only Wetland F (pool behind the Barrett House) had amphibians that need higher quality wetland such as vernal pool obligates, specifically three adult *Ambystoma maculatum* found there in April (Table 5). We observed several egg masses in this pool along with the adults. However, our May survey did not detect any larvae. The pool was mostly filled in with leaves and debris. There was no additional observation of adults or metamorphs of this species near this pool. This suggests that recruitment of salamanders from this breeding population may be variable, and longer-term monitoring is needed to determine breeding success. Wetland E (pool near Spencer Brook) did not have any *Ambystoma.* The final categorization of these wetlands by the AmphIBI index indicated that all but Wetland F are in poor health. However, it is important to mention that Wetland F is likely in

poor condition as well, but the presence of the *Ambystoma maculatum* and the lack of other species observed boosted the score enough to put it in the "superior" health category. This is likely an artifact of sampling and is not considered to be representative of the actual wetland condition.

Species Accounts

Thamnophis sirtalis

Thamnophis sirtalis (Eastern Garter Snake) is a common member of the Colubridae family found throughout eastern North America (iNaturalist 2024-c). In New England, this species can be quite abundant, and has several subspecies (Uetz and Hallermann n.d.). In Massachusetts, this species has been recorded in every county (Government of Massachusetts 2023). This snake can be found in a wide variety of habitats including riparian areas, woodlands, edges, meadows, and mountains (Jackson et al. 2010). This species is also found in disturbed urban areas (Jackson et al. 2010). Threats to this species include loss of habitat and over-collection.

During the course of this survey, *Thamnophis sirtalis* was recorded 23 times, 15 under cover, and eight incidental encounters (Table 7). The distribution of this species at the farm was primarily along the edges of the agricultural fields (Figure 7). This was likely due to the high numbers of insects and rodents around the edges of the fields that can serve as prey for this species. This species was recorded nearly every month of the survey, with the highest number of observations recorded in June (n=9) and lowest in April (n=2). August was under-surveyed, but it is likely this species was present as well (Table 7).

Table 7. Seasonality of *Thamnophis sirtalis* observed during the survey of herpetofauna at the BFU.

Date	Coverboard	Incidental Encounters
4/20/2023	1	0
4/28/2023	0	0
4/29/2023	1	0
5/6/2023	1	0
5/10/2023	0	1
5/15/2023	0	2
5/16/2023	0	1
6/2/2023	0	1
6/12/2023	3	1
6/15/2023	1	0
6/23/2023	1	0
6/30/2023	2	0
7/7/2023	1	0
7/15/2023	1	0
9/3/2023	1	1

Table 7 (continued). Seasonality of *Thamnophis sirtalis* observed during the survey of herpetofauna at the BFU.

Date	Coverboard	Incidental Encounters
9/8/2023	2	0
9/15/2023	0	1

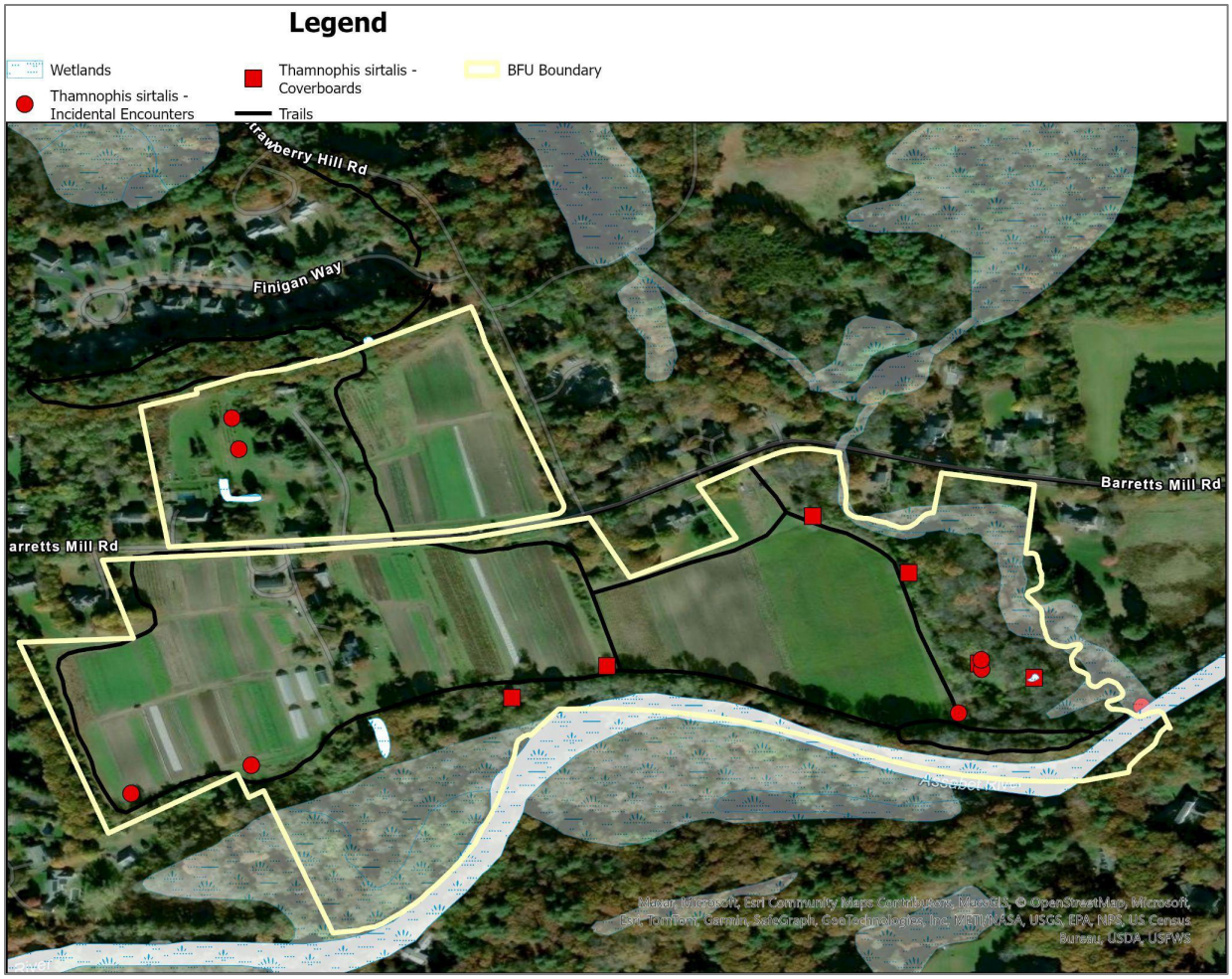

Figure 7. Locations of *Thamnophis sirtalis* observed at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Because this was the most common species of reptile recorded at Barrett Farm, it seems relatively secure at this location and is not likely to be extirpated from the site.

Image of *Thamnophis sirtalis*. Imaged May 2023. NPS / TEÁ MONTAGNA

Chelydra serpentina

Chelydra serpentina (Common Snapping Turtle) is a member of the Chelydridae family found throughout most of North America excluding the Southwest and West (iNaturalist 2024-d). In Massachusetts, this species has been recorded in every county (Government of Massachusetts 2023).

This is a freshwater species and can be found in rivers, shallow lakes, streams, and other bodies of water (Cook et al. 2011; Jackson et al. 2010). Like other turtles, this species will lay its eggs in sandy areas near to water (Government of Massachusetts 2023.; Jackson et al. 2010). Egg laying and nesting occurs from June to July (Government of Massachusetts 2023; Jackson et al. 2010).

During the course of the survey, *C. serpentina* was observed only once during the month of June (Table 8). A nest and eggs were also seen during this same month, possibly from the same adult female (Table 8). The adult was spotted along the edge of an agricultural field, and the nest and eggs were not far from that site (Figure 8).

Table 8. Seasonality of *Chelydra serpentina* observed during the survey of herpetofauna at the BFU.

Date	***Chelydra serpentina*** **Adult**	**Eggs**	**Nest**
6/2/2023	1	0	1
6/12/2023	0	1	0

Threats to this species include harvesting of eggs, destruction of habitat, and pollution of waterways. At the BFU, there is limited data on the population of this species. Because only one adult was seen, it is likely that the population does not typically nest at the site, but it does likely occur along the Assabet River. The nest and eggs were laid in a heavily trafficked area, and the survival of the eggs is unknown. Protecting future nests would be ideal to help promote this species at the site.

Figure 8. Location of *Chelydra serpentina* observed at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Chelydra serpentina. Imaged June 2023. NPS / KIAH WALKER

Chrysemys picta

Chrysemys picta (Painted Turtle) is a very common species in the family Emydidae found throughout much of North America (Jackson et al. 2010). There are several distinct subspecies of this turtle, with *Chrysemys picta picta* being found in eastern Massachusetts (Government of Massachusetts 2023). In Massachusetts, this species has been recorded in every county (Government of Massachusetts 2023).

This freshwater turtle is found in lakes, rivers, streams, and wetlands (Jackson et al. 2010). They nest in sandy areas near bodies of water (Government of Massachusetts 2023; Jackson et al. 2010). Nesting takes place from May to July (Government of Massachusetts 2023; Jackson et al. 2010).

During the course of this survey, this species was recorded by incidental encounters twice, once in May and once in June (Table 9). Both sightings were near the Assabet River while the animals were basking (Figure 9).

Table 9. Seasonality of *Chrysemys picta* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters
5/12/2023	1
6/23/2023	1

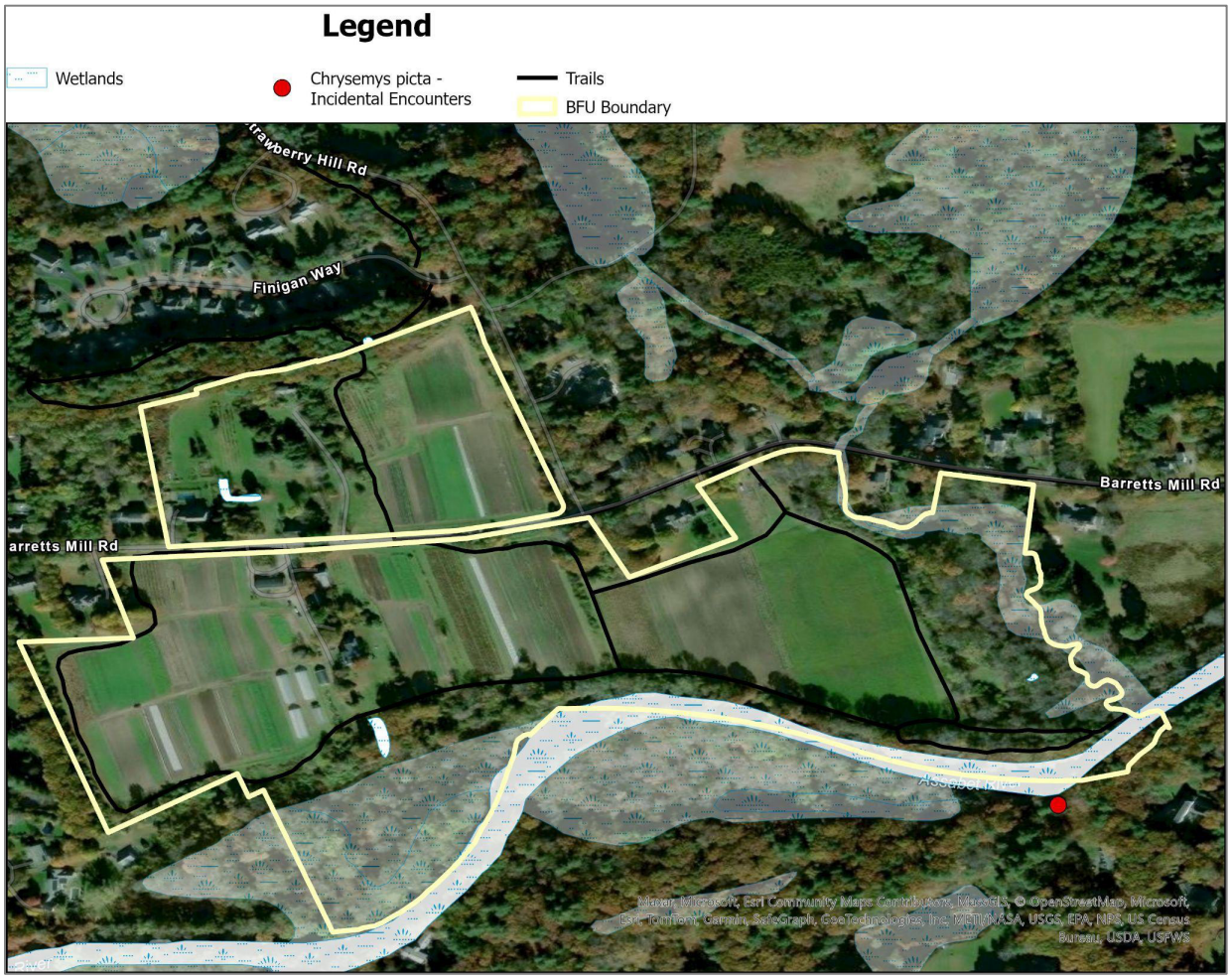

Figure 9. Location of *Chrysemys picta* observed at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Threats to this species include poaching of eggs, destruction and pollution of water bodies, and destruction of nesting sites. Given that the species was only seen in the river, it is likely not nesting at the BFU.

Chrysemys picta. Imaged May 2023. NPS / WILLIAM FUCHS

Dryophytes versicolor

Dryophytes versicolor (Gray Tree Frog) is a member of the Hylidae family and is found in the Northeast and Midwestern USA (iNaturalist 2024-f). In Massachusetts, this species is found in every county except Dukes and Nantucket (Government of Massachusetts 2023; Jackson et al. 2010).

This frog inhabits woodlands and wetlands and is highly arboreal (Jackson et al. 2010). This species typically lays its eggs in fishless ponds, vernal pools, and some man-made bodies of water like fountains and swimming pools (Jackson et al. 2010).

During the course of this survey, this species was recorded as a vocal encounter in May (Table 10). The call was coming from the back left boundary of the property near the blueberry patch (Figure 10). No visual encounters of this species were made. Threats to this species include habitat loss and destruction.

Table 10. Seasonality of *Dryophytes versicolor* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters
5/16/2023	1

Figure 10. Location of *Dryophytes versicolor* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Lithobates clamitans

Lithobates clamitans (Green Frog) is a species of frog in the Ranidae family. It is found throughout the Eastern USA, with a few populations in the Western USA (iNaturalist 2024-e). In Massachusetts, this species has been recorded in every county (Government of Massachusetts 2023; Jackson et al. 2010).

This frog breeds in freshwater areas, primarily streams, springs, swamps, ponds, and lakes (Government of Massachusetts 2023; Jackson et al. 2010). At the BFU, this species is likely breeding in the nearby marshland, as well as in the edges of the Assabet River and Spencer Brook.

During the course of this survey, this species was recorded four times under coverboards and 31 times as an incidental encounter for a total of 35 observations (Table 11). This species was found throughout the survey period (Table 11). Interestingly, we located this species in higher quantities during the beginning of the year and did not see new metamorphs later in the season. The highest concentration of sightings was in and around the pool by Spencer Brook (Figure 11). The remaining

sightings were primarily along the Assabet River, with only a handful on the other side of the street behind the Barrett House. It is possible this species is breeding at this site; a search in the pool by Spencer Brook, in Spencer Brook, and in the Assabet River for tadpoles could confirm this.

Table 11. Seasonality of *Lithobates clamitans* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters	Coverboards
4/13/2023	1	0
4/14/2023	1	0
4/20/2023	6	0
4/28/2023	1	0
4/29/2023	2	0
5/10/2023	2	1
5/12/2023	3	0
5/16/2023	1	0
5/27/2023	4	0
5/31/2023	5	0
6/12/2023	2	0
6/30/2023	0	1
7/7/2023	0	1
7/15/2023	1	0
9/15/2023	2	1

Figure 11. Locations of *Lithobates clamitans* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Lithobates clamitans. Imaged April 2023. NPS / KIAH WALKER

Lithobates catesbeianus

Lithobates catesbeianus (American Bullfrog), is a species of frog in the Ranidae family. It is native to the Eastern USA but is now found throughout the USA (iNaturalist 2024-a). It is considered invasive in many western US states (Urbina et al. 2020). They have also been introduced in many other parts of the world ((Laufer et al. 2008). In Massachusetts, this species is found in every county (Jackson et al. 2010; iNaturalist 2024-a).

This frog breeds in permanent bodies of freshwater such as streams, lakes, ponds, and marshes. They will also breed in man-made bodies of water (Government of Massachusetts 2023; Jackson et al. 2010; Urbina et al. 2020).

During the course of this survey, this species was recorded twice in September at the pool by Spencer Brook (Table 12, Figure 12). It is possible that it was the same individual seen twice at this pool. Due to lack of sightings of this species, it is unlikely for it to be breeding at this site, though habitat is suitable.

Table 12. Seasonality of *Lithobates catesbeianus* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters
9/8/2023	1
9/15/2023	1

Figure 12. Locations of *Lithobates catesbeianus* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Lithobates catesbeianus. Imaged April 2023. NPS / KIAH WALKER

Lithobates pipiens

Lithobates pipiens (Northern Leopard Frog) is a species of frog in the family Ranidae. It is found in Northern Canada, down to New York, across to Wyoming, and south to the mountains of New Mexico and Arizona (iNaturalist 2024-g). It is primarily northern or montane in distribution (iNaturalist, n.d.-g). In Massachusetts, this species is found in Bristol, Plymouth, Middlesex, Norfolk, Essex, Worcester, Hampden, Hampshire, and Berkshire Counties (Government of Massachusetts 2023; Jackson et al. 2010; iNaturalist 2024-g).

This species inhabits a wide variety of habitats including permanent ponds, lakes, swamps, marshes, and streams (Government of Massachusetts 2023; Jackson et al. 2010). They can be found in urban and agricultural areas (Knutson et al. 2018). During the summer months, the adults largely disperse and inhabit grassy areas (Northern Leopard Frog (U.S. National Park Service) n.d.). This correlates well with our findings, as one day in early September, 20 individuals were encountered along the grassy edges of the farmland (Table 13).

Table 13. Seasonality of *Lithobates pipiens* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters
4/2/2023	1
4/13/2023	1
4/14/2023	1
4/20/2023	1
5/31/2023	7
6/12/2023	3
6/23/2023	3
6/30/2023	2
7/7/2023	1
7/15/2023	5
7/22/2023	3
9/3/2023	20
9/8/2023	1
9/15/2023	3

During the course of this survey, this species was recorded 52 times as incidental encounters (Table 13). More individuals were seen later in the year. They were seen in most places around the farm with the highest concentration along the Assabet River and Spencer Brook (Figure 13). While it is unlikely for these frogs to be breeding at the BFU, the adjacent Crowley Land likely has a breeding population, and there are several more known breeding populations along the Assabet and Concord Rivers including at nearby Great Meadows National Wildlife Refuge.

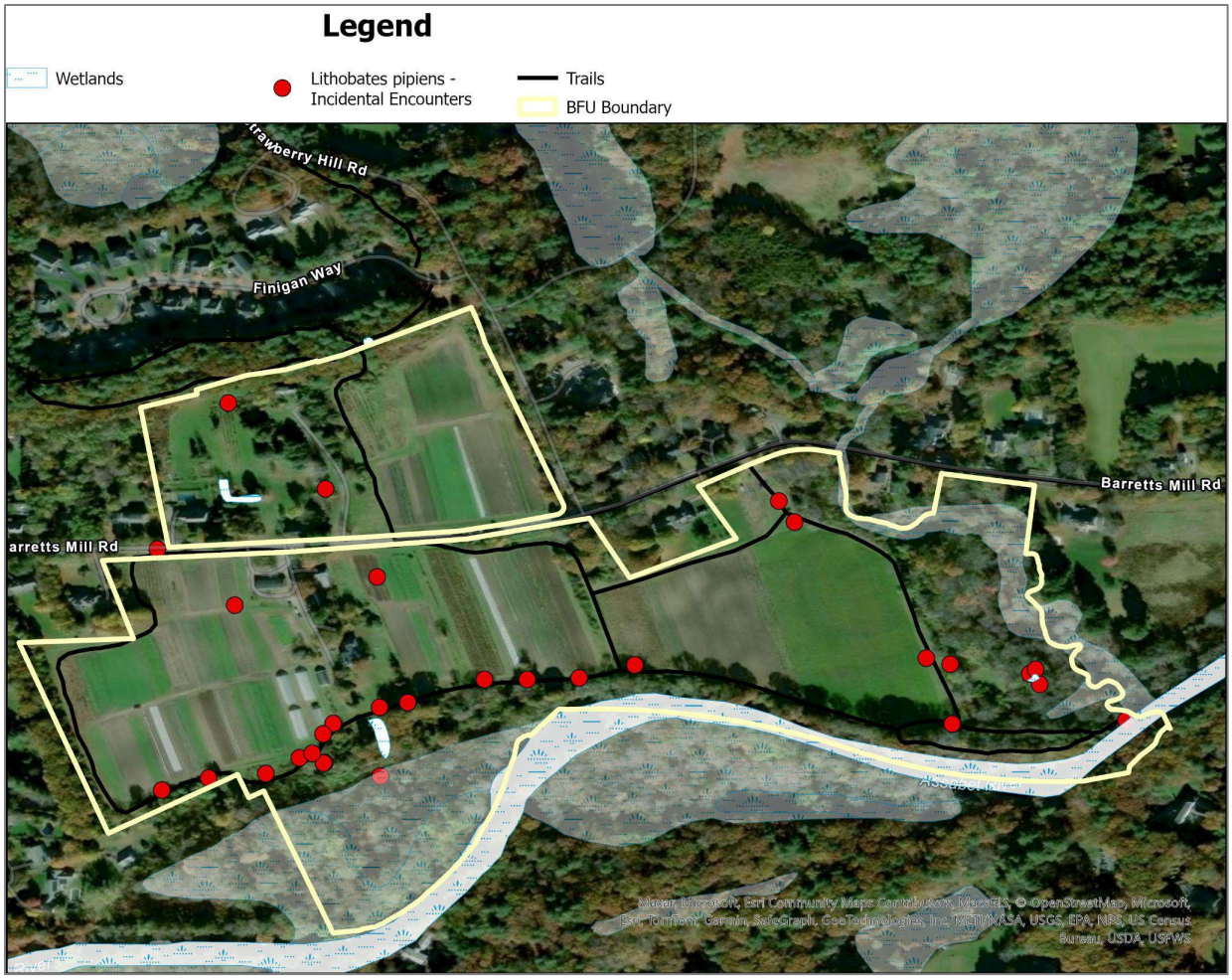

Figure 13. Locations of *Lithobates pipiens* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Lithobates pipiens. Imaged July 2023. NPS / TEÁ MONTAGNA

Ambystoma maculatum

Ambystoma maculatum (Spotted Salamander) is a species of salamander in the Ambystomatidae family. It is found throughout much of the eastern United States (iNaturalist 2024-i). In Massachusetts, this species is found in every county except Dukes and Nantucket (Government of Massachusetts 2023; Jackson et al. 2010; iNaturalist 2024-i).

This species is a vernal pool obligate and can be found in and around vernal pools in forested areas (Rothenberger et al. 2019). They breed from March to April and are often found in and around these pools during this time (Government of Massachusetts 2023; Jackson et al. 2010; Timm et al. 2007). During the remainder of the year, they are often underground (Timm et al. 2007).

During this survey, this species was seen once in April at the pool behind the Barrett House (Figure 14, Table 14). Three individuals were recorded in the pool (Table 14). A check of this pool in early May revealed no larvae and the pool mostly filled in with leaf litter and plants. It is unknown if there is a stable breeding population of this species at the BFU.

Figure 14. Location of *Ambystoma maculatum* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Table 14. Seasonality of *Ambystoma maculatum* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters
4/1/2023	3

Threats to this species include habitat loss and fragmentation, breeding habitat loss, and pollution (Newcomb Homan et al. 2003).

Ambystoma maculatum. Imaged April 2023. NPS / ROBERT STEVENSON & NINA MCDONNELL

Plethodon cinereus

Plethodon cinereus (Northern Red-backed Salamander) is a species of salamander in the Plethodontidae family. It is found in the Eastern United States from North Carolina to Quebec and west to Minnesota (iNaturalist 2024-h). In Massachusetts, it is found in every county (Government of Massachusetts 2023; Jackson et al. 2010; iNaturalist 2024-h).

This is a very common salamander found in many different habitats (Heatwole 1962; Sayler 1966). While typically they inhabit forests, they can be found in disturbed urban areas as well (Wilk et al.

2020; Sayler 1966). During this survey, seven individuals were recorded five times under coverboards (Table 15). They were seen in April, May, and September (Table 15). Each of the sightings occurred under one of two coverboards, one near Spencer Brook, and the other behind the Barrett House (Figure 15). Both coverboards are wooden and located near more forested habitat.

Table 15. Seasonality of *Plethodon cinereus* observed during the survey of herpetofauna at the BFU.

Date	Coverboards
4/6/2023	2
5/10/2023	1
5/31/2023	1
9/8/2023	2

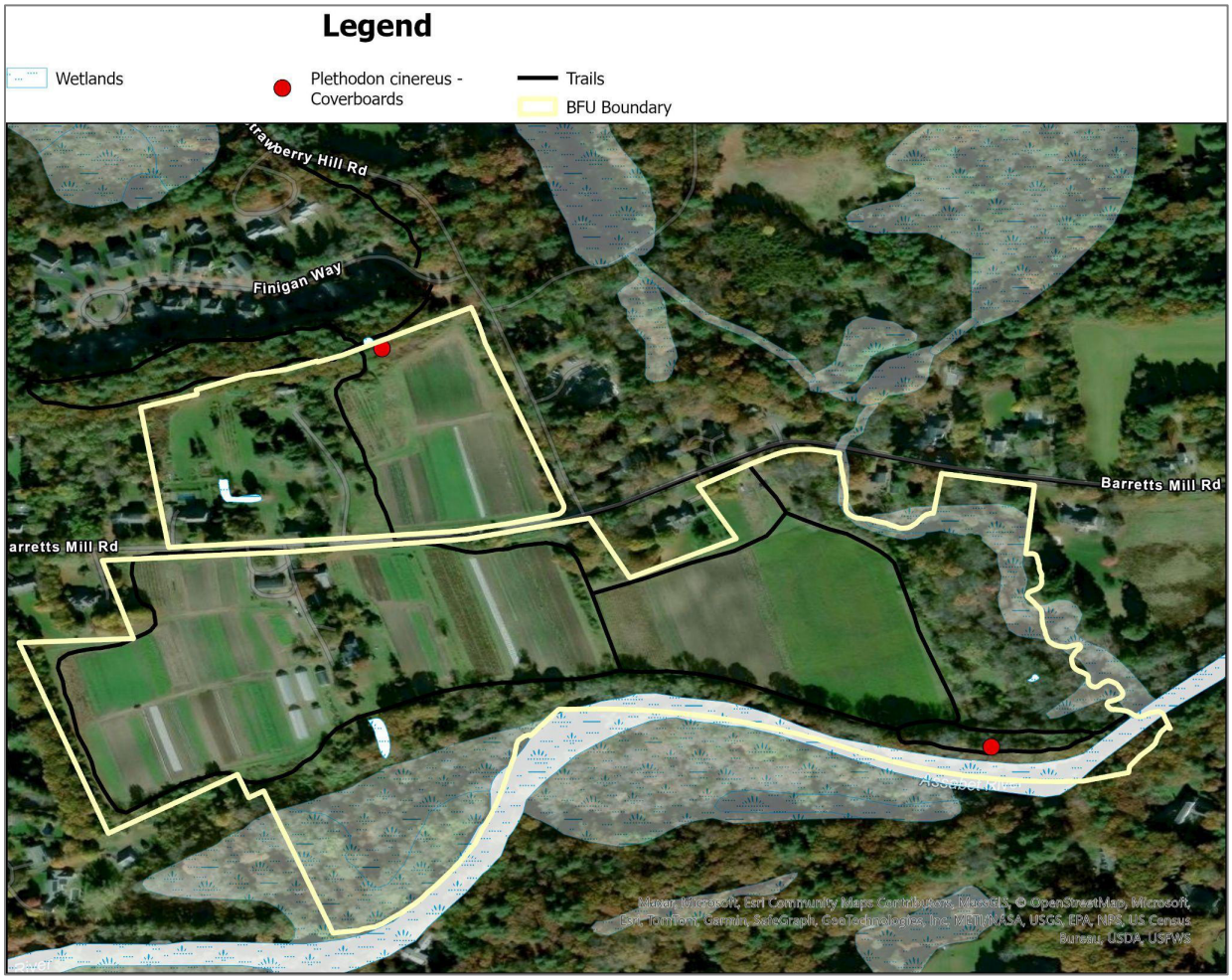

Figure 15. Locations of *Plethodon cinereus* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Threats to this species include habitat destruction and loss. Due to the sporadic sightings and extreme localization of individuals, it is unlikely this species is breeding at BFU.

Plethodon cinereus—both phases. Imaged April 2023. NPS / KIAH WALKER

Anaxyrus americanus

Anaxyrus americanus (American Toad) is a species of toad in the Bufonidae family. It is found throughout much of the eastern United States (iNaturalist 2024-b). In Massachusetts, it is found in every county except Dukes and Nantucket (Government of Massachusetts 2023; Jackson et al. 2010; iNaturalist 2024-b).

This is a widespread species that occupies many habitats. They require bodies of freshwater to breed, often in rivers, lakes, streams, ponds, marshes, and man-made pools or fountains (Christein and Taylor 1978).

During this survey, this species was encountered three times as incidental encounters, twice as visual encounters, and once vocally (Table 16). The first individual was recorded vocally in April, the second visually in July, and the last visually in September (Table 16). The encounters were all along the farmland edge by the Assabet River (Figure 16). Due to the few sightings it is unlikely this species is breeding at BFU but could be breeding nearby.

Table 16. Seasonality of *Anaxyrus americanus* observed during the survey of herpetofauna at the BFU.

Date	Incidental Encounters
4/14/2023	1
7/15/2023	1
9/3/2023	1

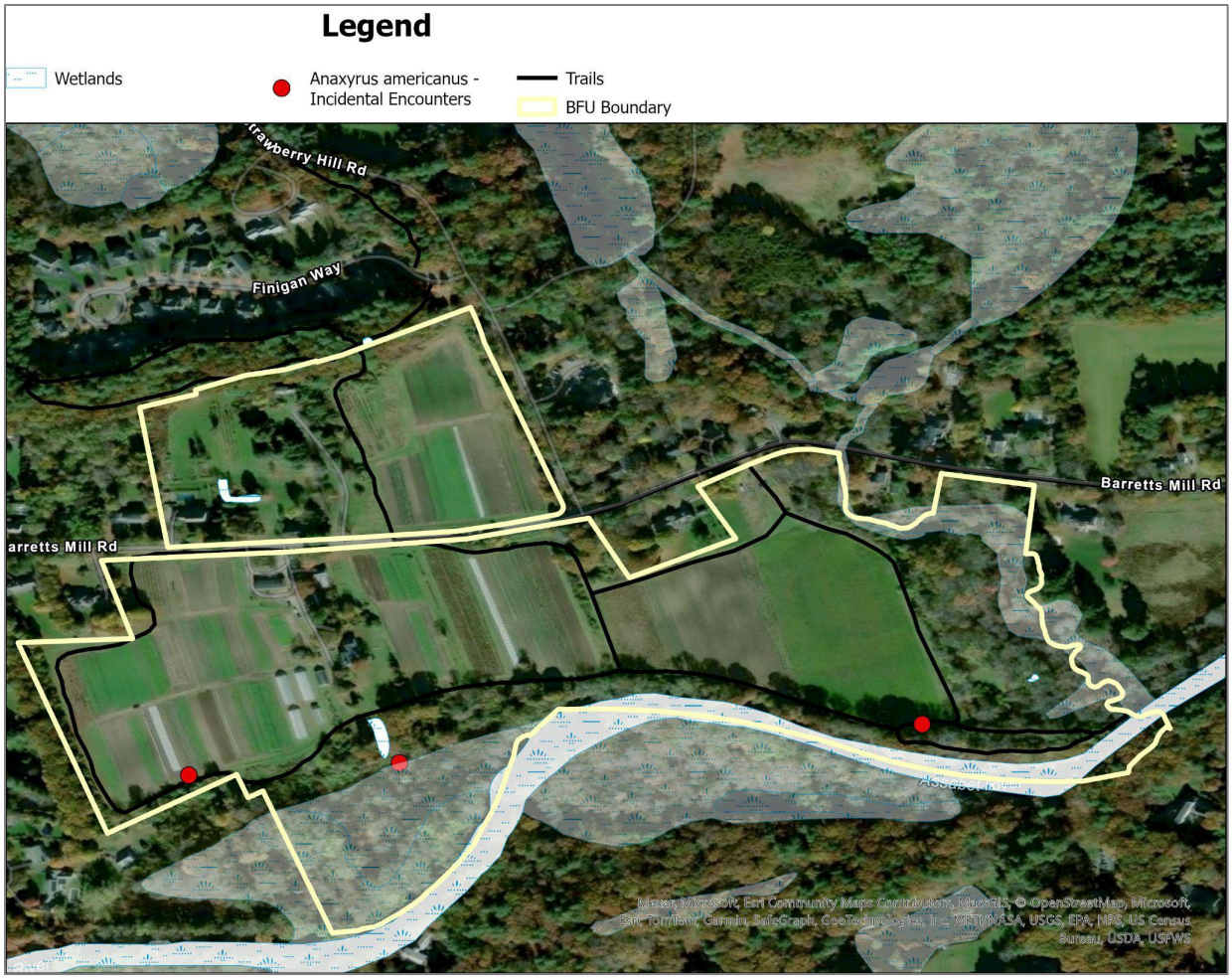

Figure 16. Locations of *Anaxyrus americanus* at the BFU. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Anaxyrus americanus. Imaged July 2023. NPS / TEÁ MONTAGNA

Birds

Description and Relevance

Birds are usually the most visible and diverse group of vertebrates in terrestrial ecosystems. Their movement, colors and vocal behaviors attract the attention of all from casual observers to professional biologists. Public interest in birds is broad. People want to know what that bird is or who is living in the neighborhood.

Since the first Christmas Bird count in 1900, birding has grown as a hobby and is now widely practiced, especially in eastern Massachusetts. Birding is an important hobby to many, and to various people can be central to a healthy lifestyle, a way to support biodiversity, or even a competitive sport. New mobile apps such as eBird and Merlin from Cornell's Laboratory of Ornithology (CLO) have accelerated the adoption of birding as a recreational activity and provided new tools for documenting sightings that can also be used as surveys.

Together these characteristics have made avian communities a priority for monitoring in NETN parks (Faccio et al. 2015). Bird monitoring programs began as early as 1992. Annual sampling became more regular in the early 2000s and spread across the network (James-Pirri 2009). The data are being used to judge ecosystem health and change. Furthermore, rare, or endangered species or species whose populations are declining can be assessed based on independent status categorizations using information from the Partner in Flight program and summarized in the State of the Birds report (2022). Ample information about the status of forest and grassland breeding birds in the northeast and across the USA is available through many different publications and reports (Robinson et al. 1995; Rosenberg and Wells 2005; Norment 2002; Brennan and Kuvlesky 2005; Askins et al. 2007; Wells et al. 2010).

Data and Methods

MIMA has supported annual, volunteer, point-count, bird monitoring for both forest and grassland species. The monitoring and assessment procedures are described by Faccio et al. (2015). Data from 2006 until 2019 show that the communities have not changed at MIMA (NPS 2018; Doser et al. 2021). Over 14 years an average of 21.5 point samples were collected per year and a total of 60 species observed at MIMA (Doser et al. 2021).

Past bird monitoring efforts at MIMA have not included Barrett's Farm, which is located west of and separate from the other park parcels. Barrett's Mill Farmland, however, is an eBird hotspot offering the opportunity to use participatory science data for assessment. The data available for hotspots are based on statistical models that provide "weekly" (48 weeks per year so it is easily divisible by 12) measures of relative abundance and a sample size. The sample size corresponds approximately to the number of checklists with corrections made to deal with the time of day, sampling duration and observer expertise (Fink et al. 2010; 2013; 2014; 2020; 2023). Data used to make the bar charts for hotspots can be downloaded from eBird by clicking "Bar charts" on the left-hand menu and then Download Histogram Data at the bottom of the page. Data between 2005 and 2023 included 455 samples, 8 of which occurred during the breeding season between the last two weeks of May and the first three weeks of June (Figure 17).

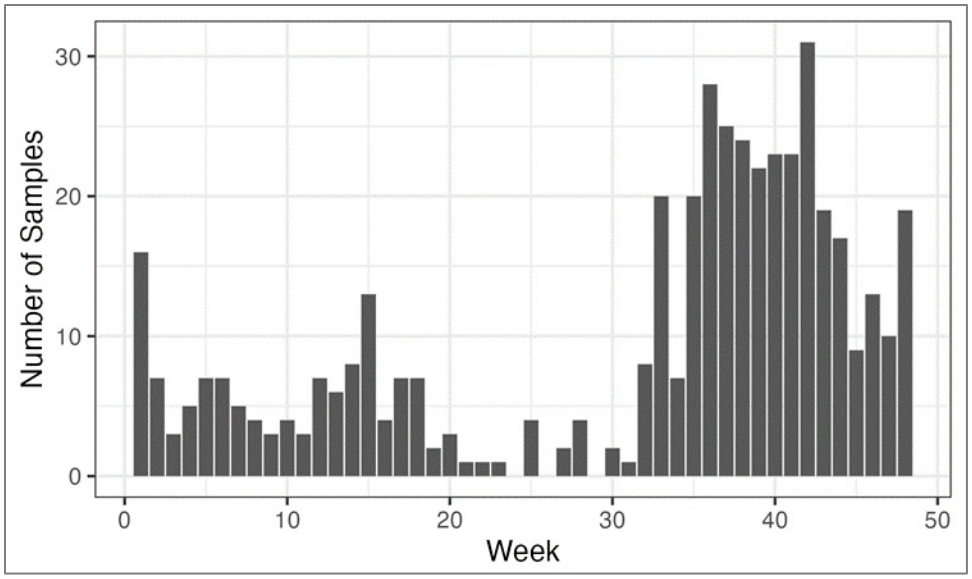

Figure 17. The number of samples in the Barrett's Farmland eBird hotspot dataset as a function of the "week" of the year, where "week" is one of the 48 equal time periods used by eBird to standardize counts. The last two weeks of May and first three weeks of June contain 8 check lists, used in the breeding bird assessment. Autumn is the most popular time to go birding at Barrett's Farm. NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

Sayornis phoebe. Imaged May 2023. NPS / ROBERT STEVENSON

Assessment Points

To assess and interpret conditions of forest and grassland bird communities, NETN has developed avian ecological integrity metrics (Faccio et al. 2015). The methods define "generalist" or "specialist" categories for each habitat type of different ecological traits (Tables 17–19). Species with more specialized traits indicate a higher degree ecological integrity, while species with more generalized straits indicate lower ecological integrity. Based on a numerical scoring system the integrity of a habitat is rated in one of three categories (good, caution, or significant concern). In the original methods point count totals were used to estimate the abundance metrics for grassland birds. The Faccio et al. (2015) method was adapted to use relative abundance in this report (Table 18).

Table 17. Avian scorecard metrics and results for forest breeding birds at Barrett's Farm based on Metric and Ratings (% Species Richness) for Functional, Compositional, and Structural groups of Response Guilds. This dataset has 8 samples from eBird comprising a total of 46 species. The method is detailed in Faccio et al. (2015). Eight of the thirteen categories score as "Cautious," with three as "Significant Concern" and two as "Good".

Biotic Integrity Element	Response Guild	Ratings (% Species Richness)			Results	
		Good	Caution	Significant Concern	Observed Percentage	Rating
Functional	Omnivore	< 30%	30–50%	> 50%	40%	Caution
Functional	Bark Prober	> 11%	4–11%	< 4%	13%	Good
Functional	Ground Gleaner	> 9%	4–9%	< 4%	2%	Significant Concern
Functional	High Canopy Forager	> 12%	7–12%	< 7%	17%	Good
Functional	Low Canopy Forager	> 22%	14–22%	< 14%	8%	Significant Concern
Compositional	Exotic	< 0.5%	0.5–7%	> 7%	6%	Caution
Compositional	Resident	< 28%	28–41%	> 41%	46%	Significant Concern
Compositional	Single-brooded	> 68%	50–68%	< 50%	56%	Caution
Compositional	Nest Predator/Brood Parasite	< 10%	10–15%	> 15%	10%	Caution
Structural	Canopy Nester	> 35%	29–35%	< 29%	35%	Caution
Structural	Shrub Nester	< 18%	18–24%	> 24%	23%	Caution
Structural	Forest-ground Nester	> 18%	5–18%	< 5%	35%	Caution
Structural	Interior Forest Obligate	> 35%	10–35%	< 10%	13%	Caution

Table 18. Avian scorecard metrics and results for grassland breeding assessment at Barrett's Farmland hotspot. This dataset has 8 samples from eBird comprising a total of 33 species. Ratings include both abundance (computed from the sum of the hotspot weekly frequencies) and % Species Richness. The method is detailed in Faccio et al. (2015) and modified here to use weekly frequencies instead of point counts to rate abundance. All the categories except the abundance of Shrub-dependent species are rated Significant Concern. There were no Grassland obligate species observed.

	Abundance (birds/point)				Barrett's Farm Status	
Guild	Good	Caution	Significant Concern	% Count Abundance	Percent Observed	Rating
Edge generalist species	< 15.0	15.0–30.0	> 30.0	> 74 %	86%	Significant Concern
Shrub-dependent species	< 1.0	1.0–5.0	> 5.0	> 12%	6.7%	Caution
Grassland obligate species	> 4.0	1.5–4.0	< 1.5	< 3.7	0%	Significant Concern
Exotic species	< 0.1	0.1–1.0	> 1.0	> 2.5	8.2%	Significant Concern

Table 19. Species richness avian scorecard metrics (see Faccio et al. 2015) and results for grassland breeding assessment at Barrett's Farmland hotspot. This dataset has eight checklists from eBird comprising a total of 49 species. All the categories are rated Significant Concern. There were no Grassland obligate species observed.

	Abundance (birds/point)				Barrett's Farm Status	
Guild	Good	Caution	Significant Concern	% Count Abundance	Percent Observed	Rating
Edge generalist species	< 35	35–70	> 70	30	88%	Significant Concern
Shrub-dependent species	< 10	10–25	> 25	3	9%	Significant Concern
Grassland obligate species	> 10	5–10	< 5	0	0%	Significant Concern
Exotic species	< 0.1	0.1–3	> 3	4	12%	Significant Concern

Condition and Trend

Forty-nine bird species were observed in the 8 samples from the hotspot data set. For forest birds the overall condition indicates "caution," with 2 guilds ranked as "good" condition, 8 as "caution" condition and 3 as "significant concern" (Table 17). For the grassland species, the metrics were much worse. For the abundance metric three of the 4 measures were of significant concern, with only the fraction of ground nesters being in the caution category (Table 18). All of the indicators based on species richness rated "significant concern." Most telling is that no grassland obligate species were detected.

Level of Confidence and Data Gaps

Confidence in the assessment is medium. The "caution" outcome for the forest birds and the "significant concern" outcome for grassland birds are not surprising given the large percentage of actively farmed acreage and large amount of edge habitat at the site. Forty-nine species were detected during the breeding season window which is about 30% of the 163 species recorded in eBird at BFU from 2005 to 2023 (Figure 18; Appendix A). The number of samples during the breeding season is small, only 8 of 445 samples (<1.8 %) compared with an expected number of 47 samples or 10.1%. With participatory science, scientists are always concerned about the quality of the data. We do not share those concerns because of the high quality of birding in eastern Massachusetts and because of the careful data reduction by the eBird analysis team at CLO. It should be pointed out that the list of the top birders for BFU includes very accomplished individuals in the birding world. The person with the most species at the site is the renowned American ornithologist and bird guide author David A. Sibley. Nonetheless we must be cautious in our inferences because the analysis depends on only 8 samples of 455 samples.

Despite our general confidence in the data and analysis, more samples during the breeding season would help.

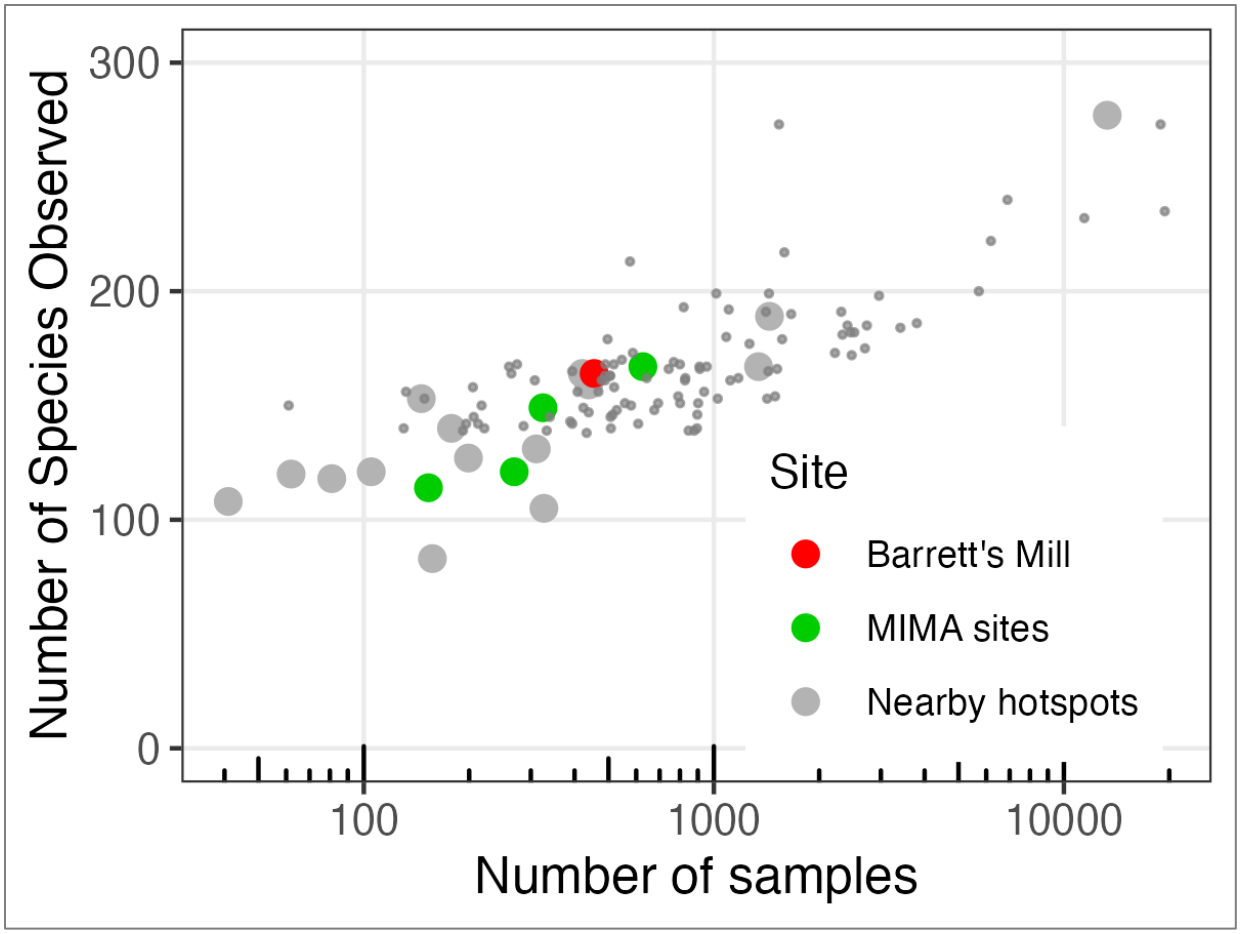

Figure 18. The number of species observed as a function of the log of the number of samples for the eBird hotspot Barrett's Farmland (red dot), nearby hotspots (large gray dots) and other MIMA sites (green dots). The small gray dots show the top 100 specious bird eBird hotspots in Middlesex County, MA. Note that species richness increases approximately linearly with the log of the number of samples. Among hotspot sites in Middlesex County, Barrett's Farmland species richness of 163 species approaches the upper limit of sites sampled with the same intensity (504 checklists). NPS / UNIVERSITY OF MASSACHUSETTS BOSTON

eDNA Results — Birds

Presented here are the eDNA detections of birds in the water samples. For methodology, please see the full write up in the reptile and amphibian section.

Avian species could be more precisely characterized by our sequences. We identified six avian species from water samples: *Cardinalis cardinalis* (northern cardinal*), Picoides pubescebs* (downy woodpecker*), Branta canadensis* (Canada goose*), Anas platyrhynchos* (mallard*), Melagris gallopavo* (wild turkey*),* and *Gallus gallus* (domestic chicken). Although turkey has not been previously reported at the BFU, this concurs with historic iNaturalist observations from the surrounding Concord land. Domestic chicken DNA may have been collected from farm associated drainage; however, it could also have been introduced through laboratory processing, as chicken egg white lysozyme is a common DNA extraction reagent.

Fish

Description

The analysis of fish communities has proven useful for assessing the health of aquatic ecosystems (Karr 1981; Karr 1991). Furthermore, recreational fishing is a cherished pastime by many citizens. Fishing occurs at the BFU in the Assabet River along the southern boundary of the property (Figure 2) and perhaps in Spencer Brook on the eastern boundary (R. Stevenson, personal observation, 2023) (Figure 2).

Data and Methods

About twenty years ago, the NPS sponsored aquatic surveys and baseline assessments of streams and ponds at seven National Parks of the Northeast Temperate Network (NETN), including MIMA (Mather et al. 2003). Based on data of Mather et al. (2003) for MIMA, additional survey information by the Massachusetts Division of Fish and Wildlife, and local bioblitzes, James-Pirri (2009) concluded that at least 22 species of fish occurred within MIMA boundaries. None of the species were considered of conservation concern. Brook trout, a sign of cold-water fisheries was found in one location. Nine of the fish species (41%) are non-native, including common species such as largemouth bass, bluegill, and green sunfish. James-Pirri (2009) completed an IBI fish assessment based on a procedure developed for New Jersey (Vile 2008). Massachusetts did not have an IBI fish procedure at the time and has subsequently adopted other metrics (see Maietta et al. 2014 and Jessup et al. 2021). The summary IBI score for each water body (Elm Brook, Mill Brook, Palumbo's Farm Pond, Unnamed Pond) was poor.

As noted above, at the time of the Mather et al. (2003) field studies and James-Pirri (2009) natural resource assessment of MIMA, the BFU was not part of MIMA. Therefore, no data were collected from the Assabet River or Spencer Brook at that time. Since then, the Massachusetts Division of Fish and Wildlife completed a fish survey that included tributaries of the Assabet River (Maietta et al. 2014). However, none of their sampling sites were close to the BFU property.

We searched for additional data on the web. The fish app, FISHBRAIN reported 9 largemouth bass, 1 perch, 1 brook trout and 1 rainbow trout caught at the confluence of the Assabet River and Spencer Book. There was very limited fish data reported on iNaturalist and none anywhere near the property. These data are insufficient to undertake an IBI calculation.

Condition and Trend

Current monitoring data were not available to assess the condition of fish at the BFU.

Level of Confidence and Data Gaps

The current status was not assessed. Fish communities have been highly altered in eastern Massachusetts by anthropogenic disturbances, especially by the movement of native fish and the introduction of non-native species (James-Pirri 2009; Native Fish Coalition 2024). Nislow (2005) suggests establishing the "original" state of fish communities is difficult.

eDNA Results — Fish

Presented here are the eDNA detections of fish in the water samples. For methodology, please see the full write up in the reptile and amphibian section.

Identification of ray-finned fish (Class Actinopterygii) was only possible to the genus level in most cases, as they fall outside of our primers' intended taxonomic range. Each Actinopterygii sequence was aligned against closest matches to determine the appropriate taxonomic level on which to base conclusions. In the cases of the *Ameiurus* genus and Cyprinidae family, potential matches could be further refined based on geographic distribution of the candidate species. For the bullhead catfish genus, *Ameiurus*, sequences matched to mitochondrial references of both *A. melas* and *A. nebulosus.* Given that only the brown bullhead, *A. nebulosus*, is found on the eastern coast of North America, this is the most likely bullhead species from the Barrett's Farm waterways. Genera of the carp family Cyprinidae are especially challenging to discern from marker gene sequences due to their great diversity and recent radiation (Saitoh et al. 2006; Wang et al. 2012). Our sequences could be narrowed down to the Cyprininae subclade (Cavender and Coburn 1992). Since only select species from this Eurasian group are established in North America, potential matches include the invasive crucian carp (*Carassius* spp.) or invasive *Cyprinus carpio* (European carp). *C. carpio* is present in at least the Concord unit of the Great Meadows system (N. McDonnell, personal observation, 2023), but both species can excel in lentic or slow-moving lotic environments, such as the lower Assabet River. *Lepomis* sunfish sequences could be diagnosed to the subdivision containing native *Lepomis machrochirus* (bluegill sunfish) and introduced *Lepomis cyanellus* (green sunfish), two likely occupants of the Spencer Brook and Assabet River waterways. We captured the most fish reads from *Esox* sp. (pickerel). The chain pickerel, *Esox niger*, and American pickerel, *Esox americanus*, both matched to our query sequence. These species are important predators in high order North American rivers and likely occupants of the Assabet.

Mammals

While no formal assessment of the mammalian community was done as a part of this report, several notable observations were made, and other observations found on the Citizen Science project iNaturalist. At several points over the survey period, mammals such as *Mus musculus* (House Mouse*), Sorex cinereus* (Common Shrew*),* and *Blarina brevicauda* (Northern Short Tailed Shrew) were found under coverboards. This is not unusual as these organisms tend to seek shelter under cover and will utilize synthetic cover. Other species recorded on iNaturalist include: *Vulpes vulpes* (Red Fox*), Canis latrans* (Coyote*), Procyon lotor* (Raccoon*), Sciurus carolinensis* (Gray Squirrel*), Sylvilagus floridanus* (Eastern Cottontail*),* and *Mustela richardsonii* (American Ermine). These mammals are all relatively common species in urban areas, except *Mustela richardsonii* which is fond of riparian areas and inhabits the nearby Great Meadows.

Sorex cinereus found under coverboard. Imaged June 2023. NPS / DANNY CALLAHAN

Our eDNA sampling also revealed several mammalian species, and in fact, mammalian species could be more precisely characterized by our sequences. We identified seven mammal species, aside from humans. These included several mesopredators: the North American opossum (*Didelphis virginiana*), northern raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and the gray wolf-domestic dog complex (*Canus lupus*). *C. lupus* had comparable mt16S identity matches to subgroups *Canis lupus lupus* and *Canis lupus familiaris*. We also identified rodent species, including the white-footed mouse (*Peromyscus leucopus*), gray squirrel (*Sciurus carolinensis*), eastern chipmunk (*Tamias straiatus),* and muskrat (*Ondatra zibethicus*). Unsurprisingly, white tailed deer (*Odocoileus virginianus*) was present in the eDNA dataset. Any ambiguities in the mammal and bird reference datasets were clearly delineated by geographic distribution.

Arthropoda

Assessment of Arthropod communities did not fall under the scope of this report, however as with mammals, several interesting observations during 2023 were made that can be included. Several Lepidoptera species were exceptionally abundant at the unit including *Colias eurytheme*, *Colias philodice, Danaus plexippus, Papilio polyxenes,* and *Phyciodes tharos*. These species all feed on herbaceous plants that are abundant in the fallow fields and edges of the farm. Of interest, two species of Sphingidae (Lepidoptera) were also recorded on iNaturalist, *Eumorpha pandorus* as a larva, and *Hemaris diffinis* as an adult. In April and May, the tiger beetle *Cicindela repanda* (Coleoptera: Cicindelidae) was exceptionally abundant along the trail leading from the parking lot toward the Assabet River. In April, many adults of *Euphoria inda* (Coleoptera: Scarabaeidae) were also present nectaring at flowers, and interestingly several were located under coverboards. The insect communities at this site are helped greatly by the addition of a native plant pollinator garden being installed near the parking area.

Celestrina sp. taking minerals from the damp sand pathway. Imaged May 2023. NPS / TEÁ MONTAGNA

Tetraopes tetrophthalmus on *Asclepias incarnata*. Imaged July 2023. NPS / TEÁ MONTAGNA

The presence of *Eubranchipus vernalis* (fairy shrimp) in the ephemeral pool near Spencer Brook was a surprise (Figure 2). These organisms are obligate in vernal pools, and the presence of them would indicate that this pool is suitable for other obligate species to breed in.

Eubranchipus vernalis. Imaged April 2023. NPS / DOUG WOODHAMS

Limitations and Future Work

Limitations of Study

2023 was an extremely wet year with above average precipitation, and this likely impacted the reptile and amphibian inventory effort. As stated in the earlier section, several boards washed away due to flooding, so it is unknown what species may occur on the floodplains more regularly. The heavy human usage of the site is another factor that impacts the results, as several boards were removed by humans, or relocated to other sites along the unit.

Due to the heavy precipitation, sampling efforts in both July and August were hampered. We were only able to visit the unit twice in July and were unable to visit in August.

Without the use of turtle trapping, we were unable to effectively inventory turtles, except for incidental encounters.

The small size of the unit and the lack of participatory science records or other studies was additionally limiting in gathering historical data. The avian fauna is particularly well understood and observed on the unit whereas other taxa such as fish, arthropods, and mammals are less well known. This reduces the quality of data we can present in this report.

Future Work

There are ample opportunities for future studies, additional work, projects, and outreach avenues at this unit. Conducting additional faunal assessments would be tremendously beneficial. It has been shown there is a huge amount of avian diversity at this site, and conducting research into this diversity and taking management steps to protect it would be beneficial. The addition of bird banding to study movement would be very interesting due to the number of unusual or sensitive bird species observed here. Examination of Arthropoda communities would be an ideal companion study as many species of bird rely on Arthropoda as prey.

It was noted that the significant presence of invasive plants is detrimental to the communities at this unit. Organizing invasive species removal workdays or similar activities with the public would have the benefits of raising public awareness of the impacts of invasive plants, as well as improving the habitat by clearing invasive plants in the unit. A second outreach project could be organizing trash clean-ups of the floodplain areas by the Assabet River.

An image of the snow-covered landscape at the BFU. Taken from the southeastern corner, looking north toward Barrett's Mill Road and Barrett's Mill Farm farmland. Imaged March 2023. NPS / TEÁ MONTAGNA

Permits

The following permits were issued in order to complete the work outlined in this document:

1. Town of Concord Conservation Land Use Permit #2023-5
2. National Park Service Scientific Research and Collecting Permit; Study #MIMA-00023, permit #MIMA-2022-SCI-0006
3. UMass Boston IACUC protocol 3446 titled “Measuring the Distribution and Abundance of Amphibians and Reptiles on Barrett’s Farm PI RD Stevenson April 2, 2023–April 2, 2025.

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Appendix A

Table 20 shows a list of species observed during this study at BFU.

Table 20. List of species recovered at the BFU along with the number and percentage of checklists that species appears in.

Common name	Scientific name	Number of Checklists	Percentage of Checklists
American Black Duck	*Anas rubripes*	21	3.8391
American Crow	*Corvus brachyrhynchos*	340	62.1572
American Golden-Plover	*Pluvialis dominica*	1	0.1828
American Goldfinch	*Spinus tristis*	377	68.9214
American Kestrel	*Falco sparverius*	11	2.011
American Pipit	*Anthus rubescens*	63	11.5174
American Redstart	*Setophaga ruticilla*	35	6.3985
American Robin	*Turdus migratorius*	423	77.3309
American Tree Sparrow	*Spizelloides arborea*	132	24.1316
American Woodcock	*Scolopax minor*	5	0.9141
Bald Eagle	*Haliaeetus leucocephalus*	14	2.5594
Baltimore Oriole	*Icterus galbula*	37	6.7642
Barn Swallow	*Hirundo rustica*	28	5.1188
Barred Owl	*Strix varia*	3	0.5484
Belted Kingfisher	*Megaceryle alcyon*	59	10.7861
Black-and-white Warbler	*Mniotilta varia*	22	4.0219
Black-capped Chickadee	*Poecile atricapillus*	413	75.5027
Black-throated Blue Warbler	*Setophaga caerulescens*	3	0.5484
Black-throated Green Warbler	*Setophaga virens*	6	1.0969
Blackburnian Warbler	*Setophaga fusca*	1	0.1828
Blackpoll Warbler	*Setophaga striata*	39	7.1298
Blue Jay	*Cyanocitta cristata*	469	85.7404
Blue-gray Gnatcatcher	*Polioptila caerulea*	18	3.2907
Blue-headed Vireo	*Vireo solitarius*	10	1.8282
Blue-winged Warbler	*Vermivora cyanoptera*	1	0.1828
Bobolink	*Dolichonyx oryzivorus*	45	8.2267
Broad-winged Hawk	*Buteo platypterus*	4	0.7313
Brown Creeper	*Certhia americana*	52	9.5064
Brown Thrasher	*Toxostoma rufum*	9	1.6453
Brown-headed Cowbird	*Molothrus ater*	114	20.841
Cackling Goose	*Branta hutchinsii*	1	0.1828

Table 20 (continued). List of species recovered at the BFU along with the number and percentage of checklists that species appears in.

Common name	Scientific name	Number of Checklists	Percentage of Checklists
Canada Goose	*Branta canadensis*	323	59.0494
Canada Warbler	*Cardellina canadensis*	2	0.3656
Cape May Warbler	*Setophaga tigrina*	1	0.1828
Carolina Wren	*Thryothorus ludovicianus*	302	55.2102
Cedar Waxwing	*Bombycilla cedrorum*	143	26.1426
Chestnut-sided Warbler	*Setophaga pensylvanica*	5	0.9141
Chimney Swift	*Chaetura pelagica*	31	5.6673
Chipping Sparrow	*Spizella passerina*	210	38.3912
Clay-colored Sparrow	*Spizella pallida*	9	1.6453
Common Goldeneye	*Bucephala clangula*	4	0.7313
Common Grackle	*Quiscalus quiscula*	161	29.4333
Common Merganser	*Mergus merganser*	6	1.0969
Common Nighthawk	*Chordeiles minor*	2	0.3656
Common Raven	*Corvus corax*	17	3.1079
Common Redpoll	*Acanthis flammea*	8	1.4625
Common Yellowthroat	*Geothlypis trichas*	85	15.5393
Cooper’s Hawk	*Accipiter cooperii*	122	22.3035
Dark-eyed Junco	*Junco hyemalis*	146	26.691
Dickcissel	*Spiza americana*	26	4.7532
Double-crested Cormorant	*Nannopterum auritum*	5	0.9141
Downy Woodpecker	*Dryobates pubescens*	330	60.3291
Eastern Bluebird	*Sialia sialis*	297	54.2962
Eastern Kingbird	*Tyrannus tyrannus*	22	4.0219
Eastern Meadowlark	*Sturnella magna*	1	0.1828
Eastern Phoebe	*Sayornis phoebe*	167	30.5302
Eastern Towhee	*Pipilo erythrophthalmus*	20	3.6563
Eastern Wood-Pewee	*Contopus virens*	29	5.3016
European Starling	*Sturnus vulgaris*	260	47.532
Evening Grosbeak	*Coccothraustes vespertinus*	2	0.3656
Field Sparrow	*Spizella pusilla*	67	12.2486
Fish Crow	*Corvus ossifragus*	1	0.1828
Fox Sparrow	*Passerella iliaca*	14	2.5594
Golden-crowned Kinglet	*Regulus satrapa*	51	9.3236
Grasshopper Sparrow	*Ammodramus savannarum*	1	0.1828
Gray Catbird	*Dumetella carolinensis*	185	33.8208

Table 20 (continued). List of species recovered at the BFU along with the number and percentage of checklists that species appears in.

Common name	Scientific name	Number of Checklists	Percentage of Checklists
Great Black-backed Gull	*Larus marinus*	3	0.5484
Great Blue Heron	*Ardea herodias*	49	8.958
Great Crested Flycatcher	*Myiarchus crinitus*	20	3.6563
Great Egret	*Ardea alba*	2	0.3656
Great Horned Owl	*Bubo virginianus*	8	1.4625
Green Heron	*Butorides virescens*	1	0.1828
Green-winged Teal	*Anas crecca*	5	0.9141
Hairy Woodpecker	*Dryobates villosus*	111	20.2925
Hermit Thrush	*Catharus guttatus*	21	3.8391
Herring Gull	*Larus argentatus*	21	3.8391
Hooded Merganser	*Lophodytes cucullatus*	2	0.3656
Horned Lark	*Eremophila alpestris*	7	1.2797
House Finch	*Haemorhous mexicanus*	352	64.351
House Sparrow	*Passer domesticus*	416	76.0512
House Wren	*Troglodytes aedon*	52	9.5064
Indigo Bunting	*Passerina cyanea*	60	10.9689
Killdeer	*Charadrius vociferus*	91	16.6362
Lapland Longspur	*Calcarius lapponicus*	3	0.5484
Least Flycatcher	*Empidonax minimus*	3	0.5484
Least Sandpiper	*Calidris minutilla*	5	0.9141
Lesser Yellowlegs	*Tringa flavipes*	4	0.7313
Lincoln’s Sparrow	*Melospiza lincolnii*	46	8.4095
Louisiana Waterthrush	*Parkesia motacilla*	3	0.5484
Magnolia Warbler	*Setophaga magnolia*	6	1.0969
Mallard	*Anas platyrhynchos*	122	22.3035
Merlin	*Falco columbarius*	10	1.8282
Mourning Dove	*Zenaida macroura*	343	62.7057
Mute Swan	*Cygnus olor*	1	0.1828
Nashville Warbler	*Leiothlypis ruficapilla*	4	0.7313
Northern Cardinal	*Cardinalis cardinalis*	436	79.7075
Northern Flicker	*Colaptes auratus*	106	19.3784
Northern Harrier	*Circus hudsonius*	11	2.011
Northern Mockingbird	*Mimus polyglottos*	352	64.351
Northern Parula	*Setophaga americana*	21	3.8391
Northern Shrike	*Lanius borealis*	4	0.7313

Table 20 (continued). List of species recovered at the BFU along with the number and percentage of checklists that species appears in.

Common name	Scientific name	Number of Checklists	Percentage of Checklists
Northern Waterthrush	*Parkesia noveboracensis*	9	1.6453
Olive-sided Flycatcher	*Contopus cooperi*	2	0.3656
Orchard Oriole	*Icterus spurius*	3	0.5484
Osprey	*Pandion haliaetus*	18	3.2907
Ovenbird	*Seiurus aurocapilla*	3	0.5484
Palm Warbler	*Setophaga palmarum*	47	8.5923
Peregrine Falcon	*Falco peregrinus*	4	0.7313
Philadelphia Vireo	*Vireo philadelphicus*	2	0.3656
Pileated Woodpecker	*Dryocopus pileatus*	58	10.6033
Pine Grosbeak	*Pinicola enucleator*	1	0.1828
Pine Siskin	*Spinus pinus*	32	5.8501
Pine Warbler	*Setophaga pinus*	23	4.2048
Prairie Warbler	*Setophaga discolor*	4	0.7313
Purple Finch	*Haemorhous purpureus*	42	7.6782
Red Crossbill	*Loxia curvirostra*	2	0.3656
Red-bellied Woodpecker	*Melanerpes carolinus*	306	55.9415
Red-breasted Nuthatch	*Sitta canadensis*	8	1.4625
Red-eyed Vireo	*Vireo olivaceus*	22	4.0219
Red-shouldered Hawk	*Buteo lineatus*	8	1.4625
Red-tailed Hawk	*Buteo jamaicensis*	231	42.2303
Red-winged Blackbird	*Agelaius phoeniceus*	202	36.9287
Ring-billed Gull	*Larus delawarensis*	11	2.011
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	42	7.6782
Ruby-crowned Kinglet	*Corthylio calendula*	60	10.9689
Ruby-throated Hummingbird	*Archilochus colubris*	32	5.8501
Rusty Blackbird	*Euphagus carolinus*	35	6.3985
Savannah Sparrow	*Passerculus sandwichensis*	200	36.5631
Scarlet Tanager	*Piranga olivacea*	16	2.925
Semipalmated Plover	*Charadrius semipalmatus*	1	0.1828
Sharp-shinned Hawk	*Accipiter striatus*	41	7.4954
Snow Bunting	*Plectrophenax nivalis*	3	0.5484
Snow Goose	*Anser caerulescens*	1	0.1828
Solitary Sandpiper	*Tringa solitaria*	7	1.2797
Song Sparrow	*Melospiza melodia*	395	72.2121
Sora	*Porzana carolina*	1	0.1828

Table 20 (continued). List of species recovered at the BFU along with the number and percentage of checklists that species appears in.

Common name	Scientific name	Number of Checklists	Percentage of Checklists
Spotted Sandpiper	*Actitis macularius*	3	0.5484
Swainson's Thrush	*Catharus ustulatus*	12	2.1938
Swamp Sparrow	*Melospiza georgiana*	100	18.2815
Tennessee Warbler	*Leiothlypis peregrina*	3	0.5484
Tree Swallow	*Tachycineta bicolor*	38	6.947
Tufted Titmouse	*Baeolophus bicolor*	342	62.5229
Turkey Vulture	*Cathartes aura*	30	5.4845
Veery	*Catharus fuscescens*	2	0.3656
Vesper Sparrow	*Pooecetes gramineus*	10	1.8282
Warbling Vireo	*Vireo gilvus*	20	3.6563
Western Kingbird	*Tyrannus verticalis*	23	4.2048
White-breasted Nuthatch	*Sitta carolinensis*	281	51.3711
White-crowned Sparrow	*Zonotrichia leucophrys*	24	4.3876
White-throated Sparrow	*Zonotrichia albicollis*	275	50.2742
White-winged Crossbill	*Loxia leucoptera*	3	0.5484
Wild Turkey	*Meleagris gallopavo*	54	9.872
Wilson's Snipe	*Gallinago delicata*	3	0.5484
Wilson's Warbler	*Cardellina pusilla*	2	0.3656
Winter Wren	*Troglodytes hiemalis*	20	3.6563
Wood Duck	*Aix sponsa*	82	14.9909
Wood Thrush	*Hylocichla mustelina*	3	0.5484
Yellow Warbler	*Setophaga petechia*	28	5.1188
Yellow-bellied Sapsucker	*Sphyrapicus varius*	16	2.925
Yellow-breasted Chat	*Icteria virens*	2	0.3656
Yellow-rumped Warbler	*Setophaga coronata*	53	9.6892

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Natural Resource Stewardship and Science
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Fort Collins, CO 80525

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